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A UNIVERSAL INDEX TO WOOD

BY E. H. F. SWAIN

Queensland Forest Service (Australia)

The writer presents a system of wood identification and classification which he believes to be comprehensive enough to include all the timbers of the world.

In the present presentation of the system, the porous woods have been dealt with completely, but the non-porous and the rayless woods are only partially disposed of, their finalisation being relegated to later times, briefly because some recourse must be had to microscopic examination to conclude the classification. In the porous series, the writer has avoided steadfastly anything more cumbersome than a hand lens scrutiny.

In the system to be described the writer has abandoned definitely the ideal of a classification of woods coinciding with or parallel to the pseudo natural botanical system of today. Woods of the same botanical genus differ so much in weight, color, and structure, and woods of different genera or even family might be so similar in these respects, that a strictly botanical basis of classification appears to be out of the question.

In any case, the main purpose of wood classification is industrial, and an industrial basis of classification appears to be requisite. Whilst this industrial basis has been adopted for the Index, the closest approach to a botanical arrangement has been sought also and it may be claimed for the system here set forth that some botanical correspondence of species has been maintained within the limits of the primarily commercial arrangement. The completed list provides for some 200,000 different woods, and will bring fairly well together in their due place

in an ascending order of density, woods of the same genus and order, so that for instance Australian timbers may fall automatically into line in the series beside their American equivalents and be available for marketing in groups under group trade names.

The Index has a decimal filing basis, employing both integers, and decimals; the integers to array woods into twenty primary groups of porous and non-porous and rayless woods, with sub-divisions according to the factors of weight and degree of porosity; the decimals to sift these primary groups down to the final unit by the application of the factors of:

(a) First Decimal Schedule—Ray density and depth of coloration of the wood.

(b) Second Decimal Schedule—(i) *(Porous woods)*—Pore density and tint of coloration of the wood. (ii) *(Non-porous woods)*—Aroma, taste, ash, or fissility.

(c) Third Decimal Schedule—*(Porous woods)*—Pore type and arrangement.

(d) Fourth Decimal Schedule—*(Porous woods)*—Ray regularity and soft tissue arrangement.

(e) Fifth Decimal Schedule—*(Porous woods)*—Special features, cleavability and ash color.

The Twenty Primary Groups succeed in assembling in sections:

(A) Coarsely Porous, very light woods having rays and pores.

(B) Finely Porous, very light woods having rays and pores.

(C) Minutely Porous, very light woods having rays and pores.

(D) Non-porous or Rayless, very light woods (with and without resin ducts).

(E) Coarsely Porous, medium weight woods having rays and pores.

(F) Finely Porous, medium weight woods having rays and pores.

(G) Minutely Porous, medium weight woods having rays and pores.

(H) Non-porous or Rayless, medium weight woods.

(I) Coarsely Porous, heavy woods having rays and pores.

(J) Finely Porous, heavy woods having rays and pores.

(K) Minutely Non-porous, heavy woods having rays and pores.

(L) Non-porous or Rayless, very heavy woods.

(M) Coarsely Porous, very heavy woods having rays and pores.

(N) Finely Porous, very heavy woods having rays and pores.

(O) Minutely Porous, very heavy woods having rays and pores.

(P) Non-porous or Rayless, very heavy woods.

First Decimal Schedule

This sorts out all the members of each primary group into ten sub-groups according to (a) the number of rays which may be counted on a transverse section within a five millimetre sample plot imprinted thereon; and (b) the depth of coloration, deep or pale, of the wood (even decimals representing colored, odd decimals representing pale woods). This schedule arrays the woods of each group into alternate color sets within a graduated scale of ray density, from the vividly silver "grained" or spangled oaks to the inconspicuously "grained" eucalypts. It has some botanical significance, since it proceeds to assemble the natural orders in the following ways:

Decimals .0 and .1 representing the pale colored and deep colored sets respectively of the "oak-grained" type, viz., those in which the rays included within the 5 millimetre plot number from 0 to 15, bring together woods of the following families: *Proteaceae, Monimiaceae, Styraceae, Sterculiaceae, and Casuarineae* (except *Casuarina lepidophloia* and *Casuarina equisetifolia); also the Palmaceae.*

Decimals .2 and .3, representing the 16-35 ray class, assemble woods of the *Capparideae, Burseraceae, Araliaceae* (except *Brassia*), *Apocynaceae, Phytolaccaceae,* and most of the *Celastrineae.* The *Meliaceae* are represented by the *Meliae* and the *Cedrelae;* otherwise its genera are scattered over all the higher ray groups up to the last, viz., 75 and over, where *Amoora* appears. The *Rutaceae* are represented by the *Flindersiae,* and the *Verbenaceae* by the *Gmelinae,* the *Laurineae* by the *Cinnamonum* and some of the *Cryptocaryae.* Such orders as the *Tiliaceae,* and the genera *Eugenia* and *Rhodamnia* of the *Myrtaceae* which have rays of two sizes are cross-indexed to these decimal classes from the 51-75 and 75 and over decimals.

Decimals .4 and .5 representing the 36-50 ray class cover most of the *Anonaceae,* the *Leguminoseae,* the genera *Pittosporum* and *Hymenospermum* of the *Pittosporae,* the genera *Owenia* and *Dysoxylon* of the *Meliaceae* and some members of the *Rutaceae, Laurineae,* and *Verbenaceae.*

In the 51-75 ray class (decimals .6 and .7) the *Sapindaceae* and the *Myoporinae* appear and the *Myrtaceae* are well represented by the genera *Melaleuca, Angophora, Syncarpia, Eugenia, Tristania* (except *Tristania laurina)* and *Rhodamnia.* The *Rutaceae* and the *Saxifrageae* are also represented strongly.

The two final sub-groups (decimals .8 and .9) with rays numbering more than 75 within the five millimetres width produce the orders

Ebenaceae and *Sapotaceae,* whilst the *Myrtaceous* genera, *Eucalyptus, Xanthostemon* and *Backhousia* occupy a large place within it. The *Myoporineae* are represented by *Eremophila,* the *Simarubae* by *Cadellia,* and the *Bixineae* by *Scolopia.*

Second Decimal Schedule (I) POROUS WOODS

This brings the porous woods of each sub-group into color tint classes (warm-toned woods represented by even decimals, cold-toned by odd decimals) and otherwise assembles woods whose degree of porosity is more or less identical. To achieve this, it relies upon a careful count of the pores to be found within an average five millimetre circular plot imprinted upon the transverse end.

The woods are grouped according to pore counts, as follows:

Coarsely Porous—1-70; 71-100; 101-150; 151-220; 221 and over.
Finely Porous—1-200; 201-400; 401-600; 601-800; 801 and over.
Minutely Porous—1-600; 601-800; 801-1100; 1101-1600; 1601 and over.

The factors of this schedule are distinctly specific in effect, and show a limited variability which is also specific in character. Occasionally they indicate the genus or order as in the case of *Ficus* and the *Celastrineae.*

(II) NON-POROUS WOODS

This divides the coniferous woods, which have passed through the primary group and the first decimal schedules, into ten classes according to aroma, taste, color of ash and fissility. It is specific in effect, and tends to a more or less greater breaking up of the groups into unit species.

Third Decimal Schedule (POROUS WOODS)

This applies to each class of porous woods, the Second Decimal Schedule, ten standard specifications of pore type and arrangements (vide Diagrams A-F). It produces a further breaking up of the family groups and genera. The effect is both generic and specific, but although the decimal has some botanical significance, the septation and arrangement of the pores do not coincide with botanical values. The factors of decimals .008 and .009 are possessed only by the *Myrtaceae,* principally by the genus *Eucalyptus,* but other individuals of the *Myrtaceae* fall also under decimals .005, .006, and .007 in associa-

tion with the *Casuarineae*. Decimals .003 and .004 claim the *Proteaceae* and a few (crossed to .3) of the *Verbenaceae*. Decimals .000 and .001 and .005, however, sort out and divide up all the other orders.

Fourth Decimal Schedule (POROUS WOODS)

The factors used in this schedule are those relating to the regularity and straightness, and uniformity or otherwise of the rays, and the presence and arrangement of soft tissue. These factors are of higher botanical significance than those of any other schedule, and they follow the natural orders quite well. They separate out at once those woods which have rays of two sizes as in the case of the *Tiliaceae*, and of the genera *Rhodamnia* and *Eugenia* of the *Myrtaceae*. The development of soft tissue is, however, often only partial and uncertain and it is this indefinition which precludes the earlier application of the test.

The following natural orders are included under the first two decimals, viz., .0000 and .0001—*soft tissue absent: Capparideae, Bixineae, Tiliaceae, Olacineae, Celastrineae, Rhamneae, Sapindaceae* (except *Atalaya hemiglauca), Myrtaceae* (with soft tissue very rarely), *Araliaceae, Verbenaceae, Monimiaceae,* and *Laurineae.*

The best examples of a wood with *soft tissue surrounding or winging the pores* (Decimals .0002 and .0003) are found in the order *Leguminosae* where soft tissue always seems to be present to some extent round the pores. *Castanospermum australe* is a good example of a wood with soft tissue winging the pores (see Diagram B).

The various woods having *soft tissue in irregularly spaced concentric lines* are very well represented in the order *Rutaceae* in which almost all the woods have this form of soft tissue. *Flindersia schottiana* is an example.

Woods showing *lines of regularly spaced soft tissue* are common in the orders *Malvaceae, Sterculiaceae,* most of the *Meliaceae,* a few of *Leguminosae, Saxifrageae, Combretaceae,* also in *Cornaceae,* common in *Rubiaceae, Epacrideae, Sapotaceae, Ebenaceae, Apocynaceae, Proteaceae, Euphorbiaceae, Urticaceae* and *Casuarinae.*

An example is *Maba fasciculosa* which like all of the *Ebenaceae* has very fine lines. *Tarrietia argyrodendron* with less bands is from *Sterculiaceae,* and *Pseudomorus Brunoniana* from *Urticaceae.*

Fifth Decimal Schedule (POROUS WOODS)

This applies the test of special features (odor, taste, greasiness, or special coloration, etc.), cleavability, and ash. It is distinctly specific

in effect. The color of the ash resulting from the burning of a small splinter is comparatively constant, *Eucalyptus paniculata* for instance, always yielding a tawny ash, *Eucalyptus resinifera* a carbon end, and *Eucalyptus microcorys* a white ash. The schedule succeeds generally in determining the final unit from among those woods which still cluster together after the passage of the six preceding factor schedule tests, as for instance in the *Eucalyptus* groups.

There are very few woods indeed which are not isolated by these tests, and these ordinarily such as are difficult to separate botanically.

The value of each decimal schedule is not intrinsic but lies in its capacity for combination with the others, and in the potency of these combinations in reducing the larger groups to smaller groups and the smaller groups to the unit species. The author believes that the six combinations of major factors given above reduce wood identities more potently than any other possible combinations.

There remains in the woodpile the nigger of variability and similarity. The same nigger, however, pops up also in the herbarium and with similar inconvenience to science.

The decimal indexing vehicle affords exceptional facilities for disposing of difficulties of variation and overlapping by the method of cross-referencing, so that a single piece of wood subject to variation may be represented not exclusively by one number, but by several, *none of which, however, will be duplicated ordinarily by any other species of wood.* Eventually all variations will be tagged under the scheme and fixed.

There are, of course, the difficulties of variation, in the observer himself as well as in his material. Some observers are not as precise as others, some have better eyesight than others and may count more pores and rays. The knife may be blunt or the transverse cut blurred. The Index is not fool-proof, but endeavor has been made to accommodate it to an average observer, by not relying upon a precise count of rays and pores but by allowing a range of fifteen to twenty-five in the case of rays, and thirty to five hundred in the case of pores.

The Index is applied in the following fashion:

1. *Apparatus*

(1) One knife with a substantial steel blade which should preferably be fixed. Generally it will be found advisable to use separate knives for softwoods and hardwoods.

(2) One oil-stone with two grades of keenness.

(3) One razor hone.
(4) One leather razor strop.
(5) A little oil.
(6) One lens with magnification of 5x approximately. (This will permit of a comparatively small view; and a lower power lens [say 2x] that will give a larger field will be found useful.)
(7) One special steel die, thumb size to mark on the transverse cut of the wood a circle of 5mm. diameter divided into four equal areas.
(8) A small plane with a keen blade.

2. *Method*

Making a transverse cut

A clean transverse cut for observation is almost impossible unless the edge of the knife is practically as sharp as that of a razor.

When cutting transverse (i. e., cross) sections it will generally be found that cutting in the same direction as the rays gives the best results. Occasionally, however, cutting at right angles to the rays is advisable as with some of the *Proteaceae*.

Applying the Index

1. Take a small piece of the wood to be identified—a piece two inches by one inch by one inch is sufficient.

2. Weigh it in the hand or in water and so determine whether it be a light wood or a heavy wood, and whether it be a very light or very heavy wood. Make a clear sharp cross-cut on the transverse end and examine the cut for porosity, whether pores be discernible or indiscernible and if discernible whether they be prominent; check with the vessel lines.

3. Find the number of the primary group corresponding to this description and put it down on paper. If in doubt between two numbers put each down separately.

4. Turn next to the second schedule—the first decimal subdivision, and taking the ray-pore plot steel thumb die, imprint on the clean transverse cut a five millimetre (one-fifth inch) diameter quartered circle. Then taking the lens, carefully count the number of rays intercepted within the five millimetre circle, and decide whether the wood be distinctly colored or colorless.

5. Find the decimal number (in the first decimal schedule) corresponding to the number of rays within the plot, and the depth of col-

oration of the wood, and put this decimal number down after the group number or numbers previously put down.

6. Turn then successively to the second, third and fourth decimal schedules, and from each schedule, select the decimal number corresponding most to the features of the wood. Place these second, third, fourth and fifth decimals successively after the number you have previously put down.

7. In this fashion you will have built up a number to five places of decimals to represent the piece of wood you have in your hand.

8. Turn up your number in the Index List. Say the number which you have so built is 10.14013 or 10.54013. In the Index List you will find a series of numbers arranged in consecutive order. You will find 10.14013 and 10.54013 to represent *Acer saccharum,* the sugar maple of North America.

There is in course of preparation as a supplement to the Index a short general description of each wood, on the following lines:

MAPLE SILKWOOD

Botanical Name—Flindersia chatawaiana.

Derivation—Flindersia after Flinders, the noted Australian explorer. *Chatawaiana* after the Hon. J. V. Chataway, M. L. A.

Synonyms—Flindersia brayleyana.

Natural Order—Rutaceae.

Type Trade Name—Maple Silkwood.

Other Vernaculars—Queensland Maple, Red Beech, Silkwood, of which the two former have been the most widely used. Silkwood has been chiefly applied to *Flindersia mazlini,* a timber which resembles *Flindersia chatawaiana* very closely indeed.

Sources of Supply—Atherton and neighboring districts, North Queensland. Does not occur elsewhere.

Color—Pale pink to moderate red, always more or less tinged with brown. The pale pink color is rare only appearing when the timber is cut from very small trees.

Figure and Scent—The figure of this timber varies considerably. Frequently the color is quite uniform throughout and there is nothing to attract the eye other than the pleasant uniform appearance. Very often, however, the features so commonly referred to as "water wave" and "bird's eye" are present. This is very beautiful and effective, being caused (principally the former) by the waving lines made by the interlocking texture to which the timber is subject.

Grain—A moderately open grained timber, the pores being just visible without straining of the eye. The vessel lines on the radial section are straighter. More or less fissile except where the texture is interlocking.

Weight and Hardness—The weight averages about 40 lbs. per cubic foot though sometimes often somewhat lighter. For hardness, compared with *Flindersia schottiana* and *Flindersia acuminata,* it is somewhat softer than the former but slightly harder than the latter.

Strength—A strong timber for its weight.

Modulus of rupture—9,000 to 10,500 lbs. per sq. inch.
Modulus of elasticity—
Elastic limit—3,100 to 3,500 lbs. per sq. inch.

Burning—Splinter burns moderately slowly with faint crackling; no smoke or exudation. Leaves a faint almost white ash (under lens shows a very faint tawny) straight, firm and adherent.

Uses and General Information—This timber and Red Cedar (*Cedrela toona var australis*) are the most esteemed of all Australian timbers for cabinet work of all descriptions, for panelling, office decorations and for railway carriage construction work. Specially esteemed for cabinet work as it "fumes" readily. Used by the Defence Department for rifle stocks and for aeroplane propellors, for the latter of which it has proved to be an excellent timber. At the present time there is no Australian timber appearing on the market which has such a variety of uses for joinery and cabinet work. When figured specially adapted for the wood of pianos.

Particular Uses and Special Advantages—Cabinet (specially) and joinery work of all descriptions. Aeroplane propellers. Dresses well and takes a fine polish. Nails hold well in it and do not rust.

Defects or Special Peculiarities—Not durable in the ground or weather if left untreated as in the case of Red Cedar. Too valuable a timber for building purposes for which it is about equal to Silky Oak and Hoop Pine.

Anatomical Features—Cross Section—A diffuse porous wood with very little variation in the sizes of the pores which can be seen by the naked eye though they do not stand out prominently. More or less with the longer axis in a radial direction but with a tendency to circular arrangement. The bars across partitioned pores are generally incomplete, the boundaries curving inwards to meet the partitions. White flecks can be seen in a number of the pores.

Rays—Just discernible to the naked eye with difficulty. Of slightly paler color than the rest of the section. They are generally straight with a more or less slight diversion by the pores which either touch one or two rays. The soft tissue is present as a thin pore edging and sometimes in thin unevenly spaced concentric lines.

Radial—The vessels are quite discernible to the naked eye and are often filled with a shiny deposit of a brownish nature. Segment bars numerous. Rays visible quite distinctly to the naked eye though not standing out as a silver grain. Of a deeper color than the background. Soft tissue not discernible.

Tangential—As the radial more or less but the rays are of the usual tangential shape and not easily discernible to the naked eye.

Index No.—8.24103.
Cross References—1.24003.

Reference to these general descriptions should enable an accurate final identification to be made of any piece of wood. The system, however, is not "fool-proof" and must be employed intelligently and carefully. Not only is wood itself variable, within certain limits, but the observer is a variable factor also. The factors of the Index have purposely been made as broad as possible, the margin of possibility of human error thereby being reduced. Users of the Index should add to the Index List their discovered numbers for authenticated woods, and the author would be grateful if lists of such new numbers were sent to him for inclusion in a later list. Due acknowledgment will, of course, be made.

The Index follows:

Universal Index to Wood

SCHEDULE I.

First division of woods into twenty primary groups, based macroscopically upon weight and porosity.

A. Very Light Woods.

(Woods, which when air dried float in water with less than 3/5ths of their bulk submerged and average under 37½ lbs. per cubic foot or sp. gr. under .6).

Aa—*Woods having both pores and rays (e. g., broad leaved trees).*

GROUP NO.

1. —Coarsely porous. (See footnote.)
2. —Finely porous. (See footnote.)
3. —Minutely porous. (See footnote.)

Ab—*Woods lacking* either *pores or rays (e. g., palms and pines).*

(1) *Weighing under 28 lbs. per cubic foot air dried—(Sp. gr. under .45).*

4. —Resin ducts or pores present.
5. —Resin ducts or pores absent.

(2) *Weighing 28 lbs. per cubic foot and over, air dried—(Sp. gr. .45 and over).*

6. —Resin ducts or pores present.
7. —Resin ducts or pores absent.

B. Moderately Light Woods.

(Woods, which when air dried float in water, with 3/5ths or more, but less than 4/5ths of their bulk submerged, and average from 37½ to under 50 lbs. per cubic foot or sp. gr. .6 to under .8.)

Ba—*Woods having both pores and rays (e. g., broad leaved trees).*

GROUP NO.

8. —Coarsely porous. (See footnote.)
9. —Finely porous. (See footnote.)
10. —Minutely porous. (See footnote.)

Bb—*Woods lacking either pores or rays (e. g., palms and pines).*

11. —Resin ducts or pores absent.
12. —Resin ducts or pores present.

C. Moderately Heavy Woods.

(Woods, which when air dried, float in water with 4/5ths or more of their bulk submerged and average from 50 to 62½ lbs. per c. ft. or sp. gr. .8 to .1.)

Ca—*Woods having both pores and rays.*

13. —Coarsely porous. (See footnote.)
14. —Finely porous. (See footnote.)
15. —Minutely porous. (See footnote).

Cb—*Woods lacking either pores or rays.*

16. —All such.

D. Very Heavy Woods.

(Woods, which when air dried sink in water, and average over 62½ lbs. per c. ft. or sp. gr. over 1.)

Da—*Woods having both pores and rays (e. g., broad leaved trees).*

GROUP NO.

17. —Coarsely porous. (See footnote.)
18. —Finely porous. (See footnote.)
19. —Minutely porous. (See footnote.)

Db—*Woods lacking either pores or rays (e. g., palms or pines).*

20. All such.

Footnote: A—Definitions.

1. *Coarsely Porous—Pores* on a clean transverse cut standing out markedly to naked eye; *vessel lines,* on fresh longitudinal face, appearing as prominent streaks.
2. *Finely porous—Pores* on clean transverse cut, small and indistinct, but discernible by the naked eye without strain; *vessel lines* on fresh longitudinal face, not prominent.
3. *Non-porous or minutely porous—Pores,* on clean transverse cut, entirely absent, or else almost wholly indiscernible by the naked eye; *vessel lines,* on fresh longitudinal face absent or quite indefinite.
4. *N. B.*—Woods containing resin ducts only should not be regarded as porous.

SCHEDULE II

First decimal subdivision of each of the twenty primary groups of woods of Schedule I into ten subgroups according to (a) the number of rays enclosed within a ray-pore plot five millimetres (1/5th inch) in diameter imprinted upon a clean cut transverse end (as seen under a hand lens of 10-x magnification), and (b) coloration of a freshly cut longitudinal surface.

SUBGROUP: *Ray Count—0-15*

No. .0 Woods distinctively colored, or variegated (see footnote 2).
No. .1 Woods uncolored or very pale colored.

SUBGROUP: *Ray Count—16-35*

No. .2 Woods distinctively colored, or variegated (see footnote 2).
No. .3 Woods uncolored or very pale colored.

SUBGROUP: *Ray Count—36-50*

No. .4 Woods distinctively colored, or variegated (see footnote 2).
No. .5 Woods uncolored or very pale colored.

SUBGROUP: *Ray Count—51-75*

No. .6 Woods distinctively colored, or variegated (see footnote 2).
No. .7 Woods uncolored or very pale colored.

SUBGROUP: *Ray Count—76 and over*

No. .8 Woods distinctively colored, or variegated (see footnote 2).
No. .9 Woods uncolored or very pale colored.

Footnote 1—Counting the Rays Within the Plot

NOTE: Count the rays *within the plot;* not merely on a line across the plot.

(1) The counting of the rays can often be facilitated by moistening the wood.

(2) Where the rays are of two kinds or exhibit an appreciable lack of uniformity count both the total number, and the number of the more prominent, using separate decimal numbers for each count as cross-references.

(3) If the count is near the border line between two decimals, cross-reference to both decimals.

(4) Woods without rays go under decimals .0 and .1.

2—Coloration

Distinctively colored—Bright pinks to reds and reddish browns; bright yellows, greens, dark greens, purples or chocolates.

Variegated—Parti-colored; or with growth ring or vascular bundle figurings deeply colored and standing out from a pale-colored ground upon the longitudinal surfaces.

Uncolored or very pale-colored—Whites, creams, pale greys, straw colors or buffs, or pale pinks or browns.

Note: Generally, the color refers to the heartwood, but sapwood may be indexed under pale colored or colorless, although heartwood be indexed under distinctively colored.

SCHEDULE III (I) (POROUS WOODS)

Second decimal subdivision of each class of *porous* woods of Schedule II into ten classes according to (a) the number of pores counted within the five millimetre diameter ray-pore plot on a clean sharply cut transverse section; (b) the color tint of the wood on a clean cut longitudinal face.

FOR COARSELY POROUS WOODS		FOR FINELY POROUS WOODS		FOR MINUTELY POROUS WOODS	
Color Tints		Color Tints		Color Tints	
Warm-toned	*Cool-toned*	*Warm-toned*	*Cool-toned*	*Warm-toned*	*Cool-toned*
(a) Bright pink to red and reddish browns; pale pinks, pale browns; straw colors or buffs.	(b) Bright yellows, greens, dark greys, purple or chocolates, whites, creams or pale grey.	(a) Bright pinks to red and reddish browns; pale pinks, pale browns; straw colors or buffs.	(b) Bright yellows, greens, dark greys, purples or chocolates, whites, creams or pale grey.	(a) Bright pinks to red and reddish browns; pale pinks, pale browns; straw colors or buffs.	(b) Bright yellows, greens, dark greys, purples or chocolates, whites, creams or pale grey.
Pore Count 1-70		*Pore Count 1-200*		*Pore Count 1-600*	
Sub-Class No.	Sub-Class No.	Sub-Class No.	Sub-Class No.	Sub-Class No.	Sub-Class No.
.000	.001	.000	.001	.000	.001
Pore Count 71-100		*Pore Count 201-400*		*Pore Count 601-800*	
.002	.003	.002	.003	.002	.003
Pore Count 101-150		*Pore Count 401-600*		*Pore Count 801-1100*	
.004	.005	.004	.005	.004	.005
Pore Count 151-220		*Pore Count 601-800*		*Pore Count 1101-1600*	
.006	.007	.006	.007	.006	.007
Pore Count 221 and Over		*Pore Count 801 and Over*		*Pore Count 1601 and Over*	
.008	.009	.008	.009	.008	.009

Footnote: N. B.—Counting Pores.

(1) *Count each compartment of septate pores as a single pore.*

The counting of the pores will be facilitated by the four equal divisions of the stamp or disc used to make the five millimetre circle imprint.

Three counts over three separate plots should be made in each case, and the maximum, average, and minimum numbers noted. There is usually a tendency to be insufficiently precise in counting, and often the count of a casual observer falls 10 per cent or even 20 per cent below that of a practiced observer. Allowance should be made for any pores smudged out by the cross lines of the stamp or die.

(2) If the count is near the border line, cross-reference to both decimals.

(3) Resin ducts in coniferous woods should not be counted as pores. (See special schedule for non-porous woods.)

SCHEDULE III (II) (NON-POROUS WOODS)

Second decimal subdivision of each class of *non-porous* woods of Schedule II into ten classes according to (a) aroma or taste; (b) color of ash; (c) fissility.

A—Woods Which Possess Either a Distinctive Aroma or a Distinctive Taste or Both

(See footnote.)

CLASS NO.

(a) Half match size splinter burns leaving a pure white ash.

.00 Wood fissile. (See footnote.)

.01 Wood not fissile. (See footnote.)

(b) Half match size splinter burns leaving an ash other than pure white, viz., tawny, grey or black.

.02 Wood fissile. (See footnote.)

.03 Wood not fissile. (See footnote.)

B—Woods Non-Aromatic and Tasteless

(See footnote.)

(a) Half match size splinter burns leaving a pure white ash.

.04 Wood fissile. (See footnote.)

.05 Wood not fissile. (See footnote.)

(b) Half match size splinter burns leaving an ash other than pure white.

(b1) Ash more or less tawny.

.06 Wood fissile. (See footnote.)

.07 Wood not fissile. (See footnote.)

(b2) Ash grey or black or absent.

.08 Wood fissile. (See footnote.)

.09 Wood not fissile. (See footnote.)

Footnote—Definitions

(a) *Distinctive aroma*—Sweet, aromatic, fragrant, spicy, etc.

(b) *Distinctive taste*—Bitter, sweet, astringent, resinous, terebinthine, etc.

(c) *Wood fissile*—Wood easily cleavable (using a strong knife), both radially and tangentially, into half match size splinters of more than three inches length, straight, and uniform in section from end to end. Wood usually soft and straight in texture.

(d) *Wood not fissile*—Wood of difficult cleavability (using strong knife); or splinter breaking off short; or splinter wavy or twisted; or splinter of irregular cross section at different points of its length. Wood usually hard or tough, or brittle or wavy or interlocked in texture.

SCHEDULE IV (POROUS WOODS)

(Foreword: This schedule applies to Porous Woods only. For Non-Porous Woods see special schedules.)

The main divisions of Schedule IV (P) are:

A. *Diffuse porous woods with septate or partitioned pores.*

B. *Diffuse porous woods with non-septate pores.*

C. *Ring-porous woods. (See .007 only, Diagram E.)*

A. *Woods with septate pores* are further subdivided into:

1. Woods in which the septa or partitions of the pores run in a direction at right angles to the medullary rays or at a tangent to the circumference of the tree.—Partitioning Tangential. (See Diagram A.)
2. Woods in which the septa of the pores run parallel to the rays or radially with reference to the growth rings of the tree.—Partitioning Radial. (See Diagram B.)

These divisions are further divided according to the number of septate pores and their compartments.

B. *Woods with non-septate pores* are further subdivided into:

1. Woods with pores separate from each other or touching with not more than two together. (See Diagram C.)
2. Woods with pores touching radially or tangentially (i. e., along the direction of the rays or at right angles thereto), but not diagonally. (See Diagrams D and E.)
3. Woods with the pores touching diagonally. (See Diagram F.)

These divisions are further divided according to the relative positions of the pores and if touching or not.

SCHEDULE IV (POROUS)

Third decimal subdivision of each sub-group of Schedule III (Porous Woods) into ten subclasses according to the arrangement of the pores. (As seen under the lens upon a clean, sharply cut transverse section.)

Note: (For Ring-Porous Woods, see .007 only; and for Non-porous woods see separate schedules).

A. Diffuse Porous Woods with Septate Pores:

(Woods in which the pores are divided into two or several compartments by septa [partitions] across the mouth of the pore.
Note: Sometimes non-septate pores more or less touch each other

[see Diagram D] but these touching pores should not be counted as septate [partitioned] pores.)

I. PORES PARTITIONED TANGENTIALLY: (See Diagram A.)

Counting within the ray-pore plot:—(1) The total number of pores, septate plus non-septate: and counting also: (2) the total number of non-septate pores plus each compartment of each partitioned or septate pore:

Proportion of Pores to Compartments

CLASS NO.	
.000	Count (1) is 75 per cent or more of count (2).
.001	Count (1) is between 50 and 75 per cent of count (2).
.002	Count (1) is 50 per cent or less than 50 per cent of count (2).

II. PARTITIONED RADIALLY. (See Diagram B.)

Proportion of Pores to Compartments

CLASS NO.

(Counting [1] and [2] as before):

.003	Count (1) is 50 per cent or more of count (2).
.004	Count (1) is less than 50 per cent of count (2).

B. Diffuse Porous Woods with Non-Septate Pores:

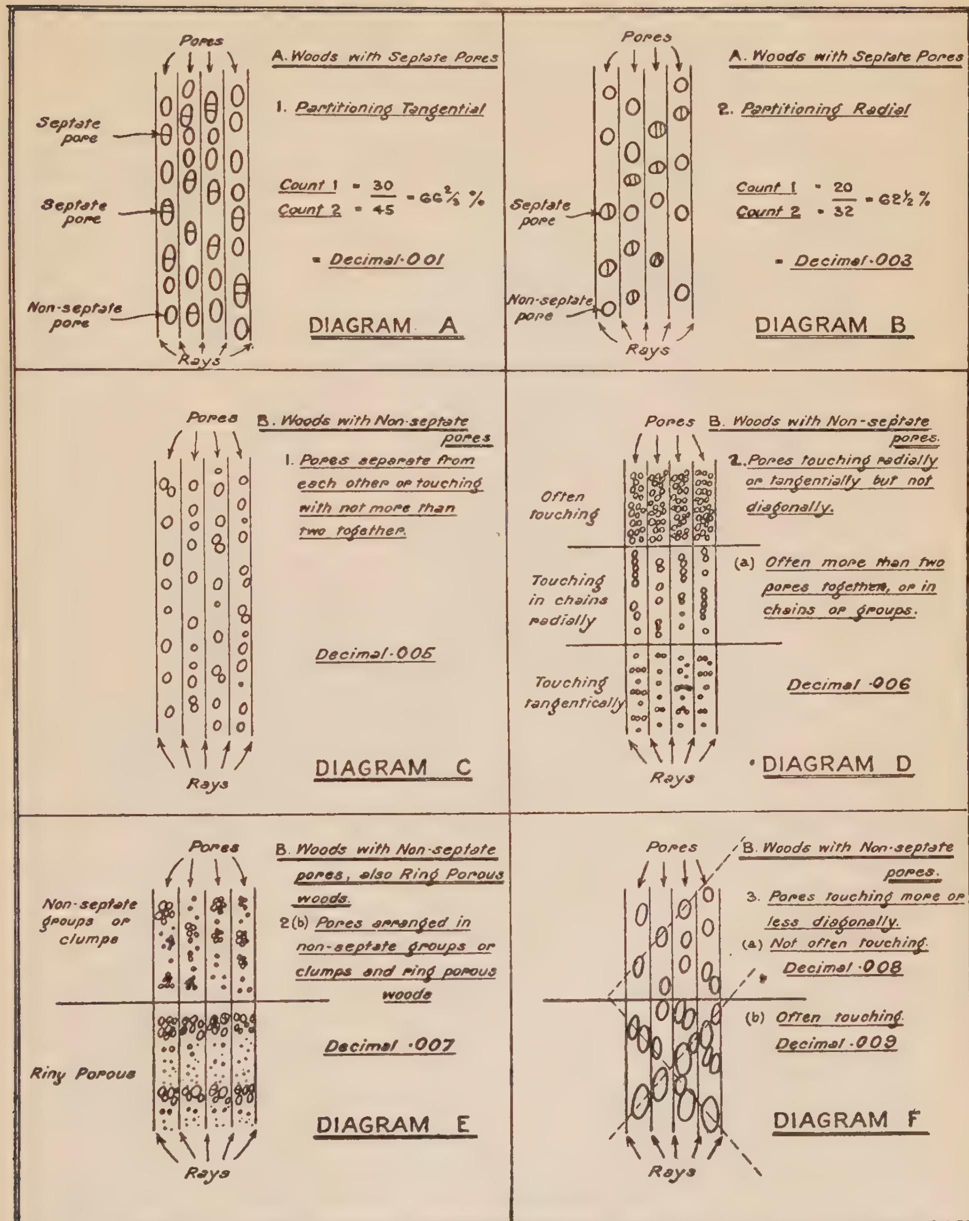
(Woods in which the pores are practically all non-septate, partitioned pores never or only very exceptionally occurring. NOTE: Sometimes unpartitioned pores may touch upon each other and give the semblance of being partitioned, but such touching pores should not be regarded as partitioned pores.)

CLASS NO.

.005 (a) *Pores separate from each other, or touching with not more than two together. (See Diagram C.)*
or:
(b) *Pores touching radially or tangentially but not diagonally. (See Diagram D.)*

.006 *Often more than two pores together, sometimes in chains or groups. (See Diagram D.)*

.007 (a) *Pores arranged in non-septate groups or clumps (See Diagram E).*
or:
(b) *Ring-porous woods. (See Diagram E.)*



Universal index to wood schedule IV (P), diagrams to illustrate pore arrangement

Pores touching more or less diagonally. (See Diagram F.)

CLASS NO.
.008 Pores not often touching.
.009 Pores often touching.

SCHEDULE V (POROUS WOODS)

Fourth decimal subdivision of each subclass of Schedule IV into ten divisions according to:

(1) *Presence and arrangement of soft tissue.*
(2) *Regularity of rays.*

(In both cases, as seen under the lens within the five millimetre ray-pore plot imprinted on a clean cut transverse section.)

A. Woods Showing No Soft Tissue:

DIVISION NO.
.0000 Rays regular. (See footnote.)
.0001 Rays irregular. (See footnote.)

B. Woods Showing Soft Tissue:

a. (i) Surrounding, edging or winging the pores, without connecting pore to pore and becoming concentric lines or bands; (See Diagrams 'A' and 'B'.)
or:
(ii) In concentric lines or bands but very irregularly and often very openly spaced. (See Diagram 'C'.)

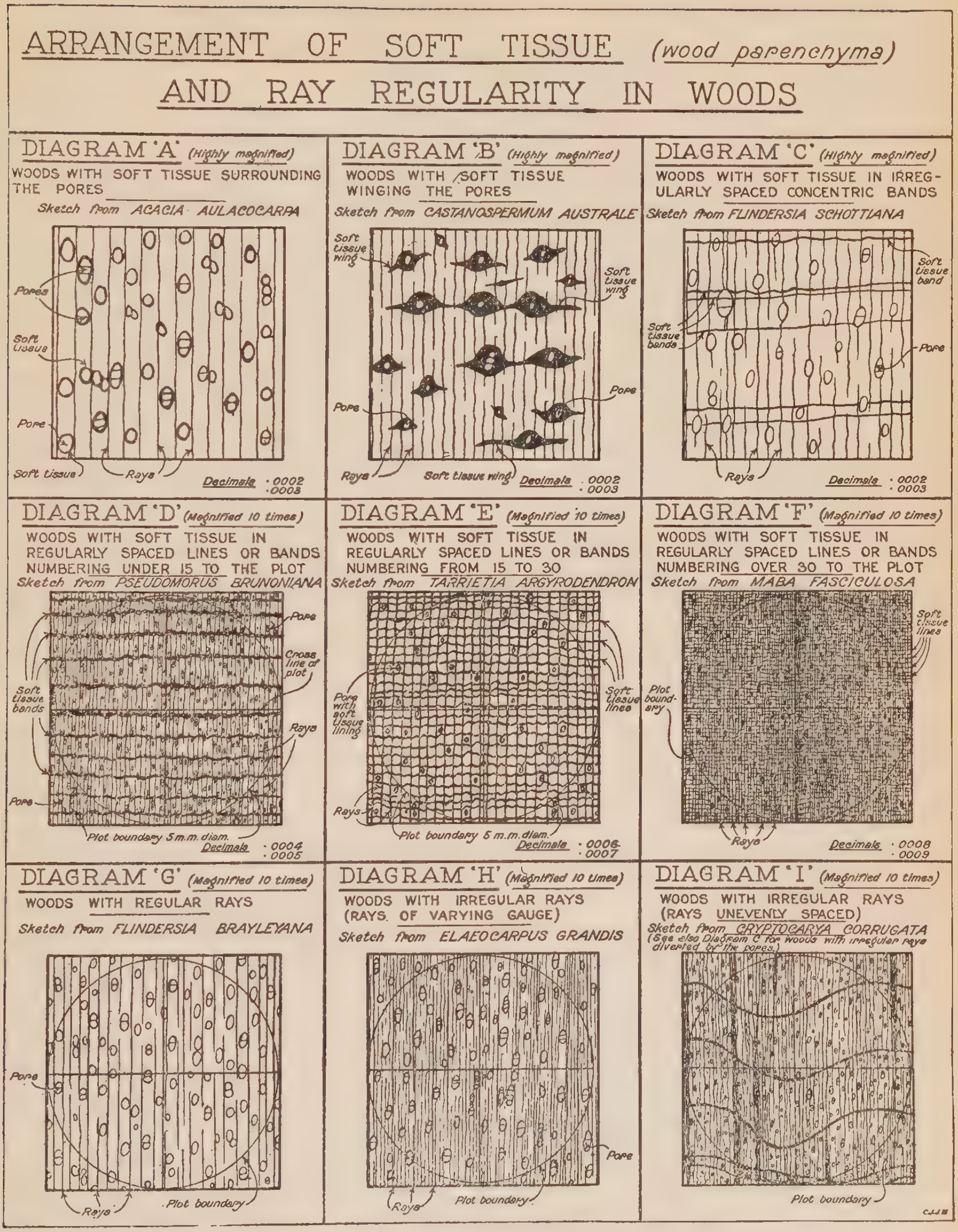
DIVISION NO.
.0002 Rays regular. (See footnote.)
.0003 Rays irregular. (See footnote.)

b. Soft tissue in concentric lines or bands more or less regularly spaced and *numbering between 2-15* within the five millimetre plot. (See Diagram 'D'.)

DIVISION NO.
.0004 Rays regular. (See footnote.)
.0005. Rays irregular. (See footnote.)

c. Soft tissue in concentric lines or bands more or less regularly spaced and *numbering between 16-30* within the five millimetre plot. (See Diagram 'E'.)

DIVISION NO.
.0006 Rays regular. (See footnote.)
.0007 Rays irregular. (See footnote.)


ARRANGEMENT OF SOFT TISSUE (wood parenchyma)
AND RAY REGULARITY IN WOODS
DIAGRAM 'A' (Highly magnified)
WOODS WITH SOFT TISSUE SURROUNDING THE PORES
Sketch from ACACIA AULACOCARPA
Pores
Soft tissue
Pore
Soft tissue
Rays
Decimals ·0002 ·0003
DIAGRAM 'B' (Highly magnified)
WOODS WITH SOFT TISSUE WINGING THE PORES
Sketch from CASTANOSPERMUM AUSTRALE
Soft tissue wing
Soft tissue wing
Pore
Pore
Rays
Soft tissue wing
Decimals ·0002 ·0003
DIAGRAM 'C' (Highly magnified)
WOODS WITH SOFT TISSUE IN IRREGULARLY SPACED CONCENTRIC BANDS
Sketch from FLINDERSIA SCHOTTIANA
Soft tissue band
Soft tissue bands
Pore
Rays
Decimals ·0002 ·0003
DIAGRAM 'D' (Magnified 10 times)
WOODS WITH SOFT TISSUE IN REGULARLY SPACED LINES OR BANDS NUMBERING UNDER 15 TO THE PLOT
Sketch from PSEUDOMORUS BRUNONIANA
Pore
Cross line of plot
Soft tissue bands
Rays
Pore
Plot boundary 5 m.m. diam.
Decimals ·0004 ·0005
DIAGRAM 'E' (Magnified 10 times)
WOODS WITH SOFT TISSUE IN REGULARLY SPACED LINES OR BANDS NUMBERING FROM 15 TO 30
Sketch from TARRIETIA ARGYRODENDRON
Pore with soft tissue lining
Soft tissue lines
Rays
Plot boundary 5 m.m. diam.
Decimals ·0006 ·0007
DIAGRAM 'F' (Magnified 10 times)
WOODS WITH SOFT TISSUE IN REGULARLY SPACED LINES OR BANDS NUMBERING OVER 30 TO THE PLOT
Sketch from MABA FASCICULOSA
Soft tissue lines
Plot boundary
Rays
Decimals ·0008 ·0009
DIAGRAM 'G' (Magnified 10 times)
WOODS WITH REGULAR RAYS
Sketch from FLINDERSIA BRAYLEYANA
Pore
Rays
Plot boundary
DIAGRAM 'H' (Magnified 10 times)
WOODS WITH IRREGULAR RAYS (RAYS OF VARYING GAUGE)
Sketch from ELAEOCARPUS GRANDIS
Pore
Rays
Plot boundary
DIAGRAM 'I' (Magnified 10 times)
WOODS WITH IRREGULAR RAYS (RAYS UNEVENLY SPACED)
Sketch from CRYPTOCARYA CORRUGATA
(See also Diagram C for woods with irregular rays diverted by the pores.)
Plot boundary
CJJB

d. In concentric lines or bands more or less regularly spaced and *numbering 31 or over* within the five millimetre plot. (See Diagram 'F'.)

DIVISION NO.

.0008 Rays regular. (See footnote.)

.0009 Rays irregular. (See footnote.)

Footnote—Definitions

Rays Regular—Rays straight in direction and not diverted from the straight line or broken by the pores; evenly spaced at regular intervals; and of uniform gauge. (See Diagram 'C'.)

Rays Irregular—Rays wavy; or diverted or broken by the intervention of pores; or unevenly spaced at irregular intervals; or of varying gauge. (See Diagrams 'H' and 'I'.)

SCHEDULE VI

Fifth decimal subdivision of each subclass of Schedule V into ten sections according to:

A. *Special features.*

B. *Fissility and burning tests.*

A. Woods having any of the following special features:

(a) *A characteristic odor when freshly cut:*
(b) *A characteristic taste:*
(c) *A distinctly greasy or sticky surface when freshly cut:*
(d) *Any of the following rare colorations:*
Black or nearly so:
Green (any shade):
Purple:
Deep yellow (sulphur):
Variegations of any kind.

SECTION NO.

.00000 (a) Wood fissile. (See footnote.)

.00001 (b) Wood not fissile. (See footnote.)

B. Woods without the special features given above (A).

(a) Half match size splinter burns leaving a pure white ash.

SECTION NO.

.00002 Wood fissile. (See footnote.)

.00003 Wood not fissile. (See footnote.)

(b) Half match size splinter burns leaving a dirty or bluish white, light grey or tawny ash.

SECTION NO.

.00004 Wood fissile. (See footnote.)

.00005 Wood not fissile. (See footnote.)

(c) Half match splinter burns leaving a dark grey or black ash, or a carbon tip less than one-third of an inch long, with large non-adherent particles of carbon mingled with an ash residue.

SECTION NO.

.00006 Wood fissile. (See footnote.)

.00007 Wood not fissile. (See footnote.)

(d) Half match spinter burns leaving no ash, or carbon end over one-third inch long without an adherent ash tip.

SECTION NO.

.00008 Wood fissile. (See footnote.)

.00009 Wood not fissile. (See footnote.)

Footnote—Definitions

(a) *Wood fissile*—Wood easily cleavable (both radially and tangentially) by a strong knife into half match size splinters of more than 3 inches in length, perfectly straight and uniform in cross section from end to end. Wood usually soft and straight in texture.

(b) *Wood not fissile*—Wood of difficult cleavability using a strong knife; or splinter breaking off short; or splinter wavy or twisted; or splinter of irregular cross section at different points of its length. Wood usually hard or tough, or brittle or wavy or interlocked in texture.

THEORETICAL CONSIDERATIONS REGARDING FACTORS WHICH INFLUENCE FOREST FIRES

By L. F. Hawley[1]
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The following discussion of the mechanism of combustion is offered in the hope that it may be of assistance in future experimental and research work on the problem of forest fire. It is based on theoretical grounds throughout, but it should not for that reason be any the less general in its application. Its anticipated usefulness, however, lies rather in its suggestion of factors for study than in any immediate relation it may bear to fire-fighting or fire-prevention methods.

Any progress of combustion in a mass of material depends on such an amount of heat being generated by the combustion of a unit of material that, under the conditions prevailing, another unit is ignited. If less than a unit is ignited the fire will "go out," and if more than a unit, the combustion will progress more or less rapidly, the rate of progress increasing with the excess heat available for further ignition. This principle is simple enough, but "the conditions prevailing" and "the excess heat available for further ignition" are governed by factors that are complex and difficult if not impossible to measure.

It is fairly well known how much heat is given off when a pound of dry wood burns, and the amount of heat given off by the same amount of wood[2] containing different percentages of water can be computed. For instance, the average total heat of combustion of various non-resinous species of wood is about 8,600 B. t. u. per pound.[3] In computing the heat of combustion practically available, however, it is necessary to subtract from the total heat the heat necessary to raise the wood and the air required for combustion from normal temperature, say 70 degrees F., to the ignition temperature of 540 degrees F. This amounts to about 1,290 B. t. u. per pound of wood, and the heat acutally available per pound of dry wood therefore is only 7,310 B. t. u. The presence of

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[2] In this case and elsewhere it will be necessary to consider wood as the typical forest fire fuel because we lack full information as to the properties of the other fuels that may be present. It is probable, however, that in fuel value and specific heat the other fuels, by reason of their cellulosic nature, are very much like wood, and it is only in these two properties that quantitative figures for wood are used.

[3] The resin from pine trees has a fuel value about twice as great as that of wood, so that a wood containing 20 per cent resin would burn with a heat of about 10,320 B. t. u. per pound.

any water in the wood further reduces the available heat by the amount required to raise the water to 212 degrees F., plus that required to volatilize the water, plus that required to raise the temperature of the steam from 212 degrees F. to the ignition temperature, say 540 degrees F. Theoretically, then, combustion could be maintained in a mass of wet wood so long as the heat of combustion was greater than that required to heat the wood to ignition, heat the water to boiling, vaporize it, and then heat the steam to the ignition point of wood. The point where the amount of water in the wood would be so great as to prevent further progress of combustion would be reached (assuming *all* the heat of combustion used to ignite more wood) when 5.71 parts water were present to one part wood.

Under the best possible conditions in practice, however, wood with that proportion of water could not be burned at all. As a matter of fact, only a small part of the heat of combustion can readily be used to ignite more fuel. In sawmills where wet sawdust is used as fuel, it is generally understood that one part water to one part wood is about the limit that can still give good fuel value, and that with two parts water to one part wood it is difficult to keep the fire from going out. If even under the conditions prevailing in a fire box only about 30 per cent of the heat of combustion can be used for ignition, a very much smaller proportion could be expected to be available in the open air and in comparatively thin layers of combustible.

The very considerable effect of the dissipation of heat by convection and radiation is shown by the well-known fact that a fire travels much less rapidly on a level than uphill. On a slope the natural upward convection currents are more nearly in the direction of the progress of the fire and the radiation from the flames to the next fuel is greater, owing to the less distance intervening. On a level expanse, however, a much larger proportion of the heat may be dissipated by convection and radiation without being useful in igniting new fuel, and consequently the effect of any moisture present in the wood is all the greater.

If for the sake of the discussion, we assume that under forest fire conditions only six per cent of the heat generated by combustion is available for ignition of more fuel (one-fifth as much as is available in wood-burning furnaces), then wood with 35 per cent moisture would be just dry enough to keep combustion going. If wood just dry enough to keep combustion going is reckoned as zero in inflammability and perfectly dry wood 100 per cent inflammable, then the effect of variations in moisture content can be rated. In this case, where 35

per cent moisture content represents zero inflammability, every reduction of 3.5 per cent in moisture content increases the inflammability by 10 per cent. If, on the other hand, conditions are such that wood with 30 per cent moisture content is just able to keep combustion going, then only a three per cent reduction in moisture content is sufficient to increase the inflammability by 10 per cent.

It is, of course, difficult to make a satisfactory assumption of the moisture content corresponding to "zero inflammability," but nevertheless there are three valuable general principles which can be deduced from this conception: (1) The moisture content above that of zero inflammability need not be considered (so far as *present* inflammability is concerned); (2) it is only variations in moisture content below that point which affect present inflammability; (3) percentage moisture below zero inflammability and percentage inflammability (with dry wood as 100 per cent inflammable) have an inverse relation. The question of quantitative measurements of inflammability is taken up in more detail in a later section.

There is another way also by which water in wood prevents or hinders combustion. In order to burn, a sufficient quantity of air must be brought into contact with the wood, and the water vapor may act as a sort of mechanical protection keeping the air away from the wood.

This brings up the general question of air supply, or wind. We all know that a match is blown *out* and a campfire is blown to make it burn; what is the difference? In the first case the heat of combustion is carried *away* from the fuel by convection to such an extent that not enough is left to ignite fresh portions of the wood. In the second case the heat is carried by convection *toward fresh fuel* which it can ignite. The main difference lies in the size of the mass of combustible. In the case of the campfire the oxygen supply, as distinct from the heat transfer, may also be an important factor, an insufficient supply being increased by the blowing.

There is no way in which the question of air supply can be treated mathematically except by showing, roughly, how much air is required to furnish oxygen for the complete combustion of a pound of wood. Theoretically, about 6⅔ pounds of air are necessary.[4] This figure assumes a complete utilization of the oxygen of the air which is almost

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[4] The effects of temperature and humidity on the volume of air required for combustion are not included here, although they are of some consequence. Warm air has less oxygen per cubic foot than cool air, and moisture in the air dilutes the oxygen in direct proportion to the volume of water vapor present. Barometric pressure also influences the amount of oxygen per unit volume of air.

impossible of attainment. Even in well-regulated furnaces where the conditions of combustion can be controlled, it is a frequent occurrence to find six to eight per cent of oxygen in the flue gases, which shows a 30 to 40 per cent excess of air used over the theoretical minimum required. It should be perfectly safe, therefore, to figure a 50 per cent excess required in forest fires, or roughly 10 pounds of air to one pound of wood. This does not sound so startling when expressed in pounds, but when translated into cubic feet it is seen that the furnishing of a sufficient air supply is a very important part of keeping a fire going. At ordinary temperatures one pound of air occupies 13.3 cubic feet, so that one pound of wood would require at least 133 cubic feet of air for complete combustion.

Furthermore, the *rate* at which this amount of air is supplied and the products of combustion are removed has an essential bearing on the intensity of the fire and the speed of its spread. Under very light wind conditions it would be difficult to furnish 133 cubic feet of air per pound of burning fuel at the necessary rate to support brisk combustion, but a fire tends to furnish its own wind from the beginning. The products of combustion are much hotter and therefore lighter than the surrounding air and rapidly rise, bringing in fresh air from all sides to take their place. But a wind generated in this manner, however much assistance it may furnish a fire in the way of providing oxygen, yet must necessarily blow *against* the direction of the travel of the fire.

When a fire first starts on a level expanse without wind it will tend to keep in a roughly circular area, with the air supplied by convection currents from the outside. When the circle is large enough, air will also be supplied by convection from the *inside* of the circle. This, however, will not act to any great extent as a wind blowing the fire forward, since the air current will be largely turned upward before it reaches the front of the fire by the heat of the ground just burned over and by the larger, slower fuel still burning in the rear of the front line of fire. Convection, therefore, can not assist the progress of the fire like a wind which actually carried the heat forward.[5]

The question has been asked, "Which would be more readily ignited, wood in equilibrium with air at 20 per cent humidity and 100 degrees F. or at 20 per cent humidity and 50 degrees F.?" and it has

[5] It has been noted, however, that a wind set up by the fire itself is even more likely to carry embers for long distances, since it tends to carry them to great heights where the prevailing breezes may carry them far before they come down.

been suggested that some experimental work be done to determine the answer. It is not even necessary to make any computations to answer the question in this form, because here both variables—temperature and humidity—work in the same direction. Both wood and duff contain less water when in equilibrium with air of 20 per cent humidity at 100 degrees F. than when in equilibrium with air of 20 per cent humidity at 50 degrees F. and therefore are more readily ignited. With equal moisture contents a fuel at higher temperature is more inflammable, and therefore on both points the 100 degrees F. fuel is more readily ignited.

There are further interesting considerations regarding the relative effects of temperature and moisture content on the inflammability of forest fire fuels, and one sees no reason why certain effects can not be determined with a fair degree of accuracy from information already available. If we assume that the inflammability increases with a decrease in the amount of heat required to raise the different fuels to the ignition point, and vice versa, it is possible to calculate relative inflammabilities from the given temperatures and humidities, together with the specific heat of wood and water and the heat of vaporization of water.

It is simpler, however, to make the computations and tabulate the results on the basis of wood with various moisture contents. The figures can then be translated into terms of duff and atmospheric humidities by using the figures in a report of M. E. Dunlap's, on file at the laboratory, entitled "The Relation of Humidity to the Moisture Content of Forest Fire Fuels." The only assumption that has to be made is that the specific heat of dry duff is the same as that of dry wood. Suppose, then, that we have a fuel with five per cent moisture content at 100 degrees F. and another with four per cent moisture and at 50 degrees F., which will be the easier to ignite? In order to heat either of them to the ignition point it will be necessary to supply a total amount of heat equal to—

(1) The heat required to raise the temperature of the wood from 100 degrees F. to 540 degrees F.

(2) The heat required to raise the temperature of the water in the wood from 100 degrees F. to 212 degrees F.

(3) The heat required to evaporate the water at 212 degrees F.

(4) The heat required to raise the temperature of the water vapor from 212 degrees F. to the ignition point.

By making computations of the values (1), (2), (3), and (4) for various temperatures and moisture contents, the accompanying Table I was prepared.

The moisture conditions of examples three and five are approximately those which would be found in equilibrium with 20 per cent humidity in the air at the temperatures shown. The effects of temperature and moisture content are both toward high inflammability

TABLE I

HEAT REQUIRED TO RAISE ONE POUND OF WOOD (DRY WEIGHT) TO IGNITION TEMPERATURE

Example No.	Initial temperature of wood	Moisture content of wood	Heat required to raise wood from initial temperature to 540°F.	Heat required to raise water from initial temperature to 212°F.	Heat required to evaporate water at 212°F.	Heat required to raise water-vapor from 212° to 540°F.	Total heat required to raise wood and contained water to ignition temperature
	°F.	Per cent	B. t. u.	B. t. u.	B. t. u.	B. t. u.	B. t. u.
1	50	3	160.0	4.9	28.9	4.9	198.7
2	50	4	160.0	6.5	38.6	6.6	211.7
3	50	5	160.0	8.1	48.3	8.2	224.6
4	50	20	160.0	32.4	193.0	32.8	418.2
5	100	4	143.6	4.5	38.6	6.6	193.3
6	100	5	143.6	5.6	48.3	8.2	205.7
7	100	21	143.6	23.5	202.6	34.4	404.1

in example 5. When the higher moisture content is combined with the higher temperature and vice versa, as in examples 2 and 6, the effect of the 50 degrees higher temperature in example 6 is a little more than enough to counteract the one per cent higher moisture. Example 6 is slightly the more inflammable of the two. In example 1, however, with two per cent less moisture and 50 degrees lower temperature than example 6, the less moisture more than counteracts the lower temperature; hence example 1 would probably be a little more inflammable than 6. Roughly, then, a decrease of two per cent moisture is a little more than equivalent to an increase of 50 degrees F. in temperature. The effect of moisture is shown decisively in examples 4 and 7.

It should be noted that these figures show that a wood with 20 per cent moisture does not require four times as much heat as one with five per cent in order to raise it to the ignition point, but instead only about twice as much. This is due to the fact that a fairly large constant amount of heat is required to heat the wood irrespective of the amount of water present.

Although the moisture content of a fuel within limits of inflammability has a large and important effect on its ease of ignition, yet

even this is of minor importance in comparison with the state of aggregation of the fuel. We all know how difficult it is to ignite a large stick of wood with a match, even if it is perfectly dry; whereas a splinter or shaving, even if it contains some moisture, is readily ignited. It is largely a question of air supply and of concentration of heating effect. When wood is in large pieces the ratio of surface to volume is so low that relatively little air is available for combustion, but in small pieces the ratio becomes much larger and all the air required for combustion is readily available. In large pieces also, the heat applied for ignition penetrates the wood only slowly, and even if the surface momentarily ignites, the heat does not travel fast enough into the wood to keep it up to the ignition temperature. Carrying these conditions to an extreme, a very finely divided wood in the form of a fine dust properly distributed in the air may be ignited by a spark and is explosive like a mixture of combustible gas and air.

The subject of ignition temperature has been left till the last because of its relative unimportance. If forest fuels were refractory—i. e., if their ignition temperature were almost as high as the flame temperature—then a few degrees difference in ignition temperature might figure largely in a study of fire conditions. If, on the other hand, the ignition temperature were extremely low—perhaps somewhere near maximum summer temperature—then a few degrees difference would be of immense importance. It happens, however, that the ignition temperatures of woods and most plant fibers lie intermediate between these two extremes, so that (1) no naturally occuring conditions except actual combustion can start a fire, and (2) the fire once started develops a temperature far higher than the ignition temperature. Hence the only effect of a moderate variation in ignition temperature would be a moderate increase or decrease of the amount of heat (shown in the last column of the table) which is required to heat the wood and water vapor to the ignition point. A difference of 50 degrees in ignition temperature (just like a difference of 50 degrees in the fuel temperature) is equivalent in its effect on combustibility to only a little more than one per cent difference in moisture content.

In the foregoing discussions everything has been considered from the standpoint of *present* combustibility, without any speculation as to how rapidly a change might take place. Nevertheless a possibility of rapid change in combustibility is readily seen to be of great importance in connection with the prediction of dangerous conditions. The moisture content is the only factor which may change rapidly, and here

again it appears that the state of aggregation of the fuel is of primary importance, in that it controls the rapidity of moisture change under given conditions of humidity. Very small, thin pieces, such as are found in the upper layers of duff, and small dead twigs, needles, and leaves are the first to dry out when the humidity is lowered. Fortunately, on the other hand, they are the first to absorb moisture from humid air or from the rain. It would be most interesting to know the quantitative relation between the surface-volume ratio of forest fuels in general and their rate of drying. It is impossible, however, to develop figures along this line without experimental work. It can only be suggested that the speed of drying is doubtless roughly proportional to the surface-volume ratio of the fuel.

In two western districts of the Forest Service a considerable body of data has been collected on the variation in moisture content of various types of quick-drying forest fire fuels, together with a record of the weather conditions during the same period. The two together offer a very good idea of the types of weather which may bring on a dangerous fire condition and even give approximate figures on the length of time required. Larger sized fuels like small limbs have not been included in these studies, perhaps because it was recognized that they are not so dangerous a fuel even when dry, and that their size prevents rapid change of moisture. In fuels of large size the lag of moisture content behind weather condition may be a week instead of only a few hours, and therefore their moisture content can be determined only by a composite of the weather conditions over a long period.

Conclusions

From a theoretical point of view the mechanism of combustion has been considered in its necessary relation to general forest conditions, including effects of temperature, moisture content, air supply, ignition temperature, heat of combustion, and state of aggregation or surface-volume ratio of fuel. Of these, the surface-volume ratio and moisture content seem the most important factors as they have the widest variation and hence the greatest change in effect. The state of aggregation outweighs all other variables affecting ease of ignition. Practically, however, from the standpoint of forecasting dangerous fire conditions, moisture content is the important factor to observe, because it may vary not only very much but very rapidly.

FORESTRY IN SWEDEN: 1925

By A. Graham, M. A.

Canada

Introduction

The belief is widely held that Swedish forest conditions are very similar to those of Canada, and that Swedish methods of forest management are therefore peculiarly worthy of the attention of Canadian foresters. To find out whether this was true or not constituted my main objective. My objects of study were more exactly: 1. The introduction of management into forests that had previously been unregulated; in particular the kind of measures adopted first and the degree of intensity aimed at in them. 2. The organization of the forest personnel. 3. Other miscellaneous points on which Swedish practice has been held up to us as an example.

I accordingly visited certain localities in central and northern Sweden where forestry was reported to be still in a somewhat elementary stage; and avoided southern Sweden altogether, as the methods in vogue there were said to be as intensive as those of Germany or France. I was particularly anxious to discover whether they employed any silvicultural "short cuts" in their less intensive operations; methods for obtaining a moderately good result at much less than the usual cost by means of striking innovations in accepted silvicultural procedure.

The main body of this report will be divided into two parts: (A) *"Description"* and (B) *"Application in Canada."*

(A) Description

I. OUTLINE OF SWEDISH FOREST CONDITIONS

Central and northern Sweden consist of undulating hilly land sloping gently upwards from the Gulf of Bothnia to a mountain chain which runs along the Norwegian frontier. This chain reaches a maximum height of about 3,000 feet, but the bulk of the forest country is below 1,200 feet. The rock is largely granite, with a covering of morainic matter; the finer clays of the valley-bottoms and lower-lying plains are cultivable, but the rocky or gravelly boulder-clays and sands in the hilly country are typically forest soils. There is also an enormous quantity of marsh and peaty ground resulting from the filling up or natural drainage of lakes; marshes and lakes are said to account for over 30 per cent of the entire surface of the country.

Central Sweden has an annual precipitation of 16 to 28 inches and a mean temperature of 37 degrees to 43 degrees Fahrenheit; the corresponding figures for northern Sweden are 16 to 24 inches and 28 degrees to 37 degrees Fahrenheit. In practice the winters in Dalarna appeared to be less severe than in Quebec, and in northern Angermanland rather similar, though the high latitude makes for a low weak sun in spring and a slower breaking down of winter conditions.

The forests in the region now being described are all of the northern coniferous type, the important species being Scots pine *(Pinus silvestris)*, Norway spruce *(Picea excelsa)*, and birch *(Betula verrucosa* or *B. alba)*. The types of stand usually met with are either pure pine on sandy soil, or a mixture of pine and spruce or of both with one of the birches. The birch does not form such a high percentage in these cases as does the paper birch under similar circumstances in Canada. Nor does the spruce appear as a swamp-dweller; there is nothing to correspond with the Canadian black spruce, and swampy situations are usually occupied by very stunted and sickly-looking pines.

Thus as far as natural conditions are concerned the parallel between central Sweden and eastern Quebec is seen to be reasonably close.

The forests are all under management of some kind. The law requires that all cut-over land shall be regenerated somehow or other but does not make any stipulations with regard to the quantities to be cut, except in Lapland where the climate is so severe that special measures are considered necessary. Inspection under this law is carried out by the "Forest Conservation Board" of the province concerned. This is a semi-official body of foresters and others who administer the forest laws and carry on education and propaganda and so forth. (An appeal from their decision can be made to the courts.) Natural regeneration is generally resorted to, or at least tried first, and poor men (e. g. farmers) are no doubt practically compelled to cut in a conservative manner by the knowledge that if natural regeneration fails they will be forced to go in for more expensive artificial methods.

The ordinary forest products are saw-lumber and pulpwood, with a certain amount of charcoal in localities that are in reach of steel-works. There is also generally some local demand for firewood. The country is exceedingly well served by rivers for driving and labor is plentiful and well distributed among the forests—partly as the result of a definite forest-colonization policy that has been pursued by the government for 30 years back.

Forest fires appear to have been conquered; a natural fire-hazard undoubtedly exists, but it does not now have to be taken into consideration in forest policy.

(N. B.—Some of the points mentioned above will be returned to and developed more fully at a later stage.)

II. NORMAL WOODS OPERATIONS

Having glanced briefly in the foregoing section at the general conditions obtaining in these forests, a particular example may now be taken of the normal woods operations of a good company.

(a) General Organization

(1) Capital (issued): 22,000,000 kronor ($5,940,000).

(2) Mills and Output: Sawmill, 25,000 standards per annum (all year work); sulphite, 36,000 tons per annum; sulphate, 24,000 tons per annum (together about 200 tons per day).

(3) Area of Property: 625,000 acres (about 980 square miles).

(4) Forestry Staff: Chief forester, assistant (highly responsible), two clerks (female), seven district officers, and one cruiser; the last member of a cruising staff now being broken up as the work is finished. He will also disappear shortly.

(5) Method of Work: The forestry department is organized on the lines of a subsidiary company; it supplies logs according to the requirements of the mills but otherwise as it thinks best, and is credited with their market value on the books. (This leads to great competition among the district foresters as regards making profits.) The chief forester is not stinted for money for regeneration or improvement work, and would consider that he had failed in his duty if the value and technical condition of the forests were not kept up. (N. B.—The general manager is a forester, and so have his two predecessors been.)

(b) Organization of a District

(1) Area: 60,000 hectares (150,000 acres or 234 square miles).

(2) Average Annual Cut: 120,000 sawlogs and 55,000 cubic metres pulpwood [say 5,000 M. B. M. (saw) and 5,500 M. B. M. (pulp) or 10,500,000 F. B. M.].

(3) Value of Cut: About 700,000 kronor on bank annually (say $2,800,000).

(4) Staff: One district officer, one cashier, one bookkeeper (in office at district headquarters), eight rangers (skogvaktare or bush foreman), 16 forest workmen (skogsarbetare or subordinate foreman), two

scalers (tummare); log measurers (afmätare), about four per ranger's district. For duties see below.

(5) Labor: Small jobbers.

(6) Specifications: Sawlogs, 13 to 23 feet long, minimum diameter six inches. Average log eight cubic feet (say about 45 F. B. M.). Pulpwood, ten feet long, minimum diameter 3½ inches. (N. B.—This is measured in stacked cubic metres of 23 cubic feet each, in which one cubic foot may represent about 4 or 4.5 F. B. M.). One solid cubic metre equals 35 solid cubic feet.

(7) Stand: About 65 cubic metres per hectare; or say 4,500 F. B. M. per acre.

(8) Rate of Growth: Assumed as two cubic metres per hectare (say 138 F. B. M. per acre) per annum. Probably more.

(9) Rotation: One hundred and twenty years for all products; pulpwood from thinnings and heads.

(c) Ranger's District

Each ranger's district being a self-contained unit a detailed description of the work in one of these will give an idea of the general procedure. What follows next is accordingly a description of one such district situated on the Västra Dalälv.

Area of district 7,500 hectares (18,750 acres or 29 square miles).

(1) Output: 15,000 sawlogs and 10,000 cubic metres of pulpwood (say 750,000 F. B. M. sawlogs and 1,000,000 F. B. M. pulp, together 1,750,000 F. B. M.).

(2) Description of Forest and Locality: The company's holdings consist of a very large number of parcels of land, purchased from farmers in the past and held in fee simple. They are in general long, narrow strips running straight up the sides of the valley, and not conforming to any natural boundaries. The intervening strips belong to farmers. The terrain is a broad and rather shallow valley with a large river and strip of cultivable flat ground varying in breadth from one-fourth mile to about one mile in breadth at the bottom, the land rising on either side to gently rolling hills of no great height. As, however, the latitude is about 61 degrees north (equal to Cape Chidley at the north extremity of Labrador) and the elevation of the valley bottom about 1,400 feet above the sea, no great additional altitude is required to produce sub-arctic conditions, and the forest accordingly gives way to a treeless plateau, less than ten miles back from the river, while the formation of peat bogs with consequent poisoning and deterioration of the soil is very common. The stand is a mixture of Norway spruce

(Picea excelsa) and Scots pine *(Pinus silvestris)* with a little birch *(Betula verrucosa)*. The spruce is considerably preponderant here, but this condition varies much from place to place. The trees are similar in appearance and size to the smaller stands of eastern Canada; the average sawlog gives about eight cubic feet, or say 40 F. B. M., and an average tree about 12 cubic feet including pulplogs and charcoal-wood in the head. (This is almost impossible to express intelligibly in terms of the Quebec log-rule.)

The soil is poor, rocky and inclined to acidity and swampiness; the growing season is short, and growth is consequently slow. It will probably take 70 years to produce pulpwood and at least 120 years for saw-lumber. The existing forest is the result of conservative and sensible but unscientific management by farmers going back for hundreds of years. The bottom of the valley is thickly populated from end to end, so that a large body of people are constantly in touch with the forest and understand every detail of logging work. No attempt is made to cultivate uncultivable ground.

(3) Logging: The trees for the winter's cutting are marked individually with a blaze and district stamp during the summer, by the bush-foreman and his assistants and with as much help and supervision from the district forester as the latter is able to give.

The cutting is done by small jobbers, who deliver the logs on the river bank, the usual price being about 60 öre per log. Logs with any considerable quantity of rot in them are not paid for at all, Swedish standards in this matter being much stricter than those of Quebec. Cutting and hauling seem to go on concurrently all through the snow season. Hauling is done with a light sleigh with two pairs of runners, and jobbers appear to find no hardship in running branch roads to groups of trees marked for felling (the group system being very commonly used, see below). The reason for this may be that the slopes are usually gentle and roads are not tied down to the lines of a few gullies. The average haul to the river is about three miles, and the maximum six miles.

The lengths of logs to be cut out of the trees are marked for the choppers by company's employes (see under "Measurer" below) who can observe at the same time whether the trees cut are those which have been blazed and stamped for cutting or not. The logs are scaled, both for purpose of working-plan record and for payment of jobbers, on the bank (see under "Scalers" below). Sawlogs and sulphate pulpwood are peeled all over by the cutters and sulphite pulpwood has three

or four strips of bark removed (depending on the size of the log) to facilitate drying.

Tenants of the company's farms also cut free firewood that has been marked for them.

(d) The duties and functions of the various members of the organization will now be given in detail, in order to show how the system corresponds to or differs from that of our own company, and to bring out those features of it on which the scientific management of the forest depend. (Particular attention will be paid to the ranger or bush-foreman, who is the key-man of the whole system.)

(1) The District Forester. This officer corresponds to an "establishment manager" in our own organization, but his duties are considerably less complicated owing to the different conditions under which he works. His prime responsibility appeared to be making contracts, delivering his quota of logs on the bank, and silviculture, i. e., the regeneration of the areas felled and the tending of the growing crops. Apart from these he had a great deal of work with lands and house-property, the company having about 400 tenants and 100 houses in his district, and he also managed a seed-extracting plant at which all the seed required for the whole of the company's sowing operations was prepared. But he was free from all responsibility in respect of the drive, as this is done by an association; of fire protection, as this is in the hands of the parish and is efficiently done (see below); and of cruising, mapping, and calculation of yield, as this is done by the head office. It also appears that the making of contracts is not a very exacting business; rates do not vary much, jobbers are content to offer prices after very little or no examination of their ground, and the forester feels himself fairly safe in going by the advice of the bush-foremen, who prepare the contracts for their districts and forward them to the forester's office for signature. Men filling this position are graduates of the Forest Academy and possess the highest technical qualifications.

(2) The Bush-Foreman or Ranger. This man has always risen from the ranks; he has started with the advantage of the Swedish public education (which is among the best in the world), and then, after proving himself a good man in the forest, has been sent to a rangers' school where he has received a year's course of technical instruction. His pay is 3,000 kronor per annum, with a small farm that may perhaps bring in an additional 300 kronor per annum; it is misleading to express this in Canadian currency, but actually it represents about double the pay

of a laborer, exclusive of the value of the farm. It is worth while to give a schedule of such a foreman's duties throughout the year.

September and October. Walks with contractors with the assistance of his two "forest workmen" or subordinate foremen. Drafts contracts and submits them to the district forester with his suggestions as to prices. (Contracts are given about the end of October.)

November to April (inclusive). Supervises jobbers' cuttings and his own men marking off log lengths. Supervises delivery and piling of logs at river. Assists scaler when he visits his district. Marks any further trees required for felling that may have been missed during marking operations in summer.

May (i. e., the four or five weeks after the snow has melted). Walks over the felled areas very carefully with the two forest workmen, noting logs left in the bush and high stumps. For these the jobbers are fined.

June and till mid-July. Supervises gangs of men sowing (one to four gangs of up to ten men each). Lays out drains. Marks thinnings and especially firewood supply for tenants to cut.

July (remainder) and August. Marks trees for following winter's cut with assistance of forest workmen and under advice from district forester. Supervises clearing up of spaces opened in previous winter (see below under "Silviculture").

Good men suitable for this position appear to be plentiful. Dishonesty and collusion with jobbers is rare and does not ordinarily have to be guarded against.

(3) The Forest Workmen (subordinate foremen). These are men who have been proved to be reliable and useful, but who have not been to the rangers' school; they are in fact in process of acquiring their practical experience and qualifications. They are paid 1,500 kronor per annum, which is the same as a laborer, but have a free farm in addition. They assist the bush-foreman in the activities detailed above and take charge of gangs for sowing or other silvicultural work, building camps, work with survey parties, etc.

(4) The Scaler. This man ranks on an equality with the bush-foreman; one scaler travels around four bush-foremen's districts. His duty is to measure the length and top diameter of each log, making deductions for rot. The logs, being of all lengths, have to be rolled out separately for this measuring. He also measures up the stacks of pulpwood, which are paid for by the stacked cubic metre. Deductions may

be made either by reducing length to the length of sound timber (in a sawlog), or else by reducing diameter as in our own practice. The former seems to be done very commonly.

(5) The Log-Measurer. This man marks off the trees, when felled, into log lengths, being guided by a table showing the most profitable dimensions. One measurer can look after five or six gangs of three choppers each (sometimes two; say, 15 choppers in all), visiting each gang twice a day. The forester assured me that this man paid for himself by the increased value of the sawlogs produced.

(6) Labor. As has been said labor is plentiful and of a good quality. The local farmers are all experienced in logging work and the conditions in the company's lots are so similar to those in their own that they can make contracts much more easily than a Canadian jobber who may be going into a totally new piece of forest. Also they are so near their homes that although they generally have to camp in this district, their problems as to portaging and supply are very simple. In some forests they can work from their homes. In consequence to this abundance of labor the company is not at all afraid of its jobbers, and has no hesitation in getting rid of one who does not observe his conditions, or in imposing conditions which a French-Canadian jobber would find intolerable, such as the cutting of marked trees only, and taking stumps down to four inches from the ground.

The usual arrangement is to have a gang of three choppers (or two if the haul is long) furnishing one horse, the jobber himself being the teamster. There may probably be a fifth man on the job, too, to help here and there as required.

A laborer is usually paid about six kronor per day, but provides his own food at a cost to himself of 1½ to 2 kronor per day.

(e) Silviculture and Management

It is the policy of this company to restrict their cut to the amount of the increment, but in calculating the yield consideration has been given to the fact that much of the growing-stock is over-mature or slow-growing through lack of thinning at an earlier stage. Consequently as far as I could gather the yield actually being taken was the ideal increment that the forest would put on when under management, calculated on a conservative basis. In marking the cut the forester only seemed to be guided by such calculations in a general way, and his actual operations were really governed by the silvicultural requirements of the area under treatment. In other words the working-plan was not a rigid one; calculations of yield were used for purposes of general

control only, and details were left very much to the discretion of the man on the spot.

The inventories had all been made on a 10 per cent basis by a head office organization, and good topographical maps of the whole country are available from the government.

Unless special circumstances demand the clear cutting of large blocks when planting or seeding must be resorted to in order to fulfill the law, all operations aim at natural regeneration. The ordinary method of obtaining natural regeneration is by felling small groups of up to two acres in size but generally under one acre; this was in use wherever I went on this company's lands, and was being carried out exactly as prescribed in the text books. On some areas selective cuttings were also going on, not with the intention of regenerating the crop tree by tree, as in the true selection system of the text books, but rather as a late thinning intended to accelerate the growth of the rest of the stand during the time remaining before it became due for removal through the gradual enlargement of the groups.

The selective cuttings had begun 15 years ago to replace diameter-limit cutting, but by groups more recently; the intention was to revisit and enlarge the groups after 20 or 25 years and so on until the whole of the old crop was gradually removed. The growth of young trees on natural openings similar to these groups indicated that this was a safe and satisfactory way in which to procure the regeneration of the crop. Thinnings other than the selective cuttings above mentioned were hardly made on a serious scale, though the forester was trying to push them on where they would pay for themselves through sale of firewood or charcoal material; and also made the marking of the tenants' fuel-wood into an opportunity for thinning. No special measures were taken to remove birch, as it was not very abundant and the leaves were expected to have a beneficial effect on the somewhat peaty soil. Great care was taken, however, to cut down all small trees, birch, etc., on the group openings, so as to leave them absolutely clear of shadow and encumbrances; a gang of men was detailed for this work regularly during the summer.

Slash is left on the ground quite untouched. It is true that utilization down to 3½ inches in the head, or to 1½ inches in places where charcoal can be made, mitigates the slash considerably, and that pine and Norway spruce do not carry such a weight of branches as white spruce and balsam fir, but the accumulation on the clear-cut openings

is nevertheless considerable. It is not, however, believed that this will interfere with the young growth.

If natural regeneration fails, or if large areas have to be cut clean for any reason, no difficulty is made about planting or sowing (generally sowing), though the chief forester generally prefers distributing his operations and increasing the time taken to log a given locality to incurring the cost of artificial regeneration. (Actually a great deal of sowing was in progress in this district at the time.)

These silvicultural operations of marking groups, thinnings, and selection cuttings, impressed me very much, as they demand fairly intensive work on the part of the personnel (very intensive by Canadian standards), and were being done exceedingly well considering the circumstances. There was no question here of taking any short cuts to silvicultural results.

III. MODIFICATIONS OF THE NORMAL SCHEME

(a) Local Conditions

The foregoing section describes a kind of normal scheme of operations, as practiced by a strong and good company. It will now be worth while to remark upon some modifications of this scheme, as observed under different economic or natural conditions.

As has already been said the silvicultural methods adopted in the district described were comparatively intensive. The group system of its very nature demands an intensive and detailed knowledge of the forest on the part of someone (in this case the bush-foreman), and being surprised to find it in use at all in such places I naturally expected that in still wilder districts or under less favorable economic conditions I should encounter something much less ambitious. But this expectation was entirely wrong, as I found on visiting another company which was in the hands of its creditors and was being worked with the object of making as much money as possible as quickly as possible, subject to carrying out the minimum requirements of the government. To judge by the managing director's conversation, one would have expected that here, if anywhere, less intensive and more wholesale methods would have been adopted. But in point of fact this was not the case. The methods adopted where in theory the same as I had seen elsewhere, while the difference lay in the way in which they were applied, as this company simply did its silviculture less carefully than the other, and accepted the natural consequence, namely, that the saving in money entailed a worse result.

The forests of this company which I visited were similar to those which have been described above, but they were lower-lying, the soil seemed richer, and the timber was certainly larger. Conditions as to labor, prices, extraction, and fire were also similar. Exploitation took the form of thinnings or the opening of groups, but the latter were much larger and less carefully arranged than in the other company's operations and one gathered the impression that a good deal was left to luck. In the last resort they planted or sowed; the forester favored the use of two-year seedlings, which could be obtained very cheaply. But it was interesting that even here every tree that was cut was blazed by the bush-foreman or the forester himself, and that no diameter-limit or other automatic artifice was in use. Thinnings occupied a larger place in the operations here as it was possible to make charcoal economically out of birch and small produce, owing to the proximity of railway transport.

A more considerable departure from the first company's scheme was exemplified in the operations of one which owns about 500,000 hectares (1,950 square miles) in northern Angermanland and southern Lapland from which it is at present taking about 30 million board feet per annum for sawlogs and sulphate and sulphite pulpwood. The chief forester has 13 district foresters and 30 bush-foremen, which represents a larger staff per unit of area than that of the company first described. The following extract from my diary is worth quoting in full:

"This village is on the 64th parallel of latitude, and at a height of about 750 feet above the sea. The surrounding country is rolling or hilly, and is very similar to that lying south of Lake Kenogami. Lakes and swamps are numerous but the lakes are generally large and form part of the system of floatable waterways. Average haul to floatable stream is about three miles, often much less. The soil is peaty in the hollows, but on the slopes is good, being formed of glacial deposits. The summer is very short on account of the high latitude, and the winter severe; details on the effect of this on the tree growth will be given below.

"The area has been inhabited for a very long time by Lapps, Finns, and Swedes successively, and there is now a plentiful but poor peasant population which is admirably adaptable to forest work.

"The species are as elsewhere pine and spruce, but the birch is very much more plentiful and vigorous than farther south; it is in fact a different species, *B. alba* in place of the more southern *B. verrucosa.*

(b) Method of Work

"The chief forester has carried out a very important series of experiments, on the results of which his policy in logging appears to be based. He found, what is indeed obvious, that the growth of these woods in their natural state was very slow indeed, both on account of their density when young, the presence of much birch, and the shortness of the growing season. He discovered, however, that not only the first two but the last of these conditions also could be remedied by thinning. He found by observation of soil temperatures that the admission to the soil of the sun's heat in spring by means of heavy thinnings resulted in the very much earlier thawing of the frozen ground, and that a temperature high enough for tree growth might be attained nearly five weeks earlier by this means than under natural conditions. In view of his experiments, and also of the overcrowded condition of many of the stands which was in itself sufficient to restrict growth enormously, he has started on a campaign of thinning and clearing by which all the company's woods will be systematically treated; birch will be cleared away wherever its suppressing effect appears to outweigh any advantage to be gained from its leaves in improving the soil, and young overcrowded stands will be opened out and given full growing space. In the latter operation many of the trees left are necessarily old, but in this case those are favored which have not made much height growth, as it is believed that they have more vigor left for recovery. As no charcoal wood is taken, any of the produce of these thinnings that is too small for pulp is left lying on the ground.

"The other logging operations are either ordinary regeneration fellings or the improvement of stands that have been damaged by past operations under a diameter-limit. Regeneration fellings are normally carried out by means of large group openings (up to five acres but usually less) or by simply removing the remaining overwood from ground that is already regenerated. If necessary recourse will be had to clean cutting followed by sowing or planting.

"Improvement after diameter-limit operations was done as follows: In the winter over-mature saw timber was taken out and driven in the spring in the usual manner. In the following summer the inferior pulpwood, i. e., small trees that had been just saved by the diameter-limit, was cut and stacked for drying to be driven in the following spring (this is an ordinary practice, to improve its floating power). Then finally a cleaning was made which removed the bad young growth, so as to leave nothing but good stock to grow up for the future.

"All these operations of course entail the marking of the trees to be taken, except the thinning out of dense young stands in which case a gang is sent in under a trained foreman with instructions to clear out the trees to a certain spacing calculated to represent the desired number of stems per hectare. Nothing was attempted even in this wild and distant locality without the marking of trees, and Mr. Aminoff of the Government Forestry Service told me later that the same was true of the State forests even in the extreme north of Lapland. Operations are carried out in general on the system described in detail above.

(c) Yield

"The thinnings and regeneration fellings are arranged so as to remove about one cubic metre per hectare which is calculated to be the increment at present. The forester is bound down to this as a maximum for the properties in Lapland, owing to a special forestry law that affects that province only—elsewhere yield is not prescribed though the land must be regenerated. He hopes that in 20 years or so his operations will have resulted in such an increased increment that he may be able to cut 1¾ or 2 cubic metres per hectare. The total cut of 235,000 cubic metres is distributed as 150,000 cubic metres outside Lapland and 85,000 cubic metres inside Lapland."

Thus we may say, by way of summarizing this and the foregoing section, that of the two strong companies that have been described, the first devotes much money and care to regeneration of a healthy young crop without undue delay, doing far more than the government regulations absolutely demand, and that the second practically makes the increase of the yield of its forests during the next rotation, the basis of its entire policy of operating. The government also takes this view, and goes in for the necessary expenditure on forests situated even in the arctic portion of the country. At the same time, a weak company is seen to have been unable to evolve any fundamental modification of the ordinary systems for the purpose of reducing costs, and to content itself simply with rather less efficient work. Consequently, as far as the first of my objects of study is concerned we must conclude that Swedish forestry is comparatively intensive even in its early stages and in unfavorable situations, and that we can not look to Sweden for revolutionary innovations in forestry practice such as might provide us with a solution to any of our problems out of hand.

IV. THE COST OF FORESTRY IN SWEDEN

(a) Standards of Comparison

The important question now remains as to how much Swedish operations cost. To make an authoritative general statement of such a question as this would of course require special study and considerable knowledge of the whole economic situation of the country, and to this I can not pretend. But some examples of the costs of individual operations may be given, and these will serve to give a general idea of the extent to which money is spent on the forests in certain areas.

The first necessity, however, is to arrive at a standard of comparison between Swedish and Canadian costs, as to translate Swedish money into its exchange value of Canadian money without taking into account the local purchasing power of either is bound to be misleading. I have accordingly taken the rate of wages current in each country as a basis, and have modified the face value of the figures in accordance with the proportion so established. Thus in Dalarna a forest laborer is paid six kronor per day without keep, while a similar man in the Province of Quebec at $40 per month and with keep worth 65 cents per day would cost $2.30 per day. As the dollar is now worth about 3.70 kronor, we thus find 6.00 kronor in Sweden buying labor that would cost 8.51 kronor in Quebec. In other words, costs that are ruled by forest wages should be increased in the proportion of 8½:6 to give their proper equivalent, i. e., they should be multiplied by 1.42.

Certain costs, however, such as those for marking trees, measuring logs, and so on are dependent not on the cost of labor but on that of subordinate supervision, and while the wages of bush-foremen in Canada vary considerably from one establishment to another it is safe to say that no bush-foreman could be obtained at as little as twice the figure for forest labor given above, i. e., about $960 per annum without keep. But as silvicultural work might be given to subordinate but trained men who would be cheaper than a full-blown bush-foreman it might be safe to do no more than double Swedish costs in these cases to give approximately corresponding figures for Quebec.

Wages were lower in the north so that on the foregoing principle the last company's costs for "labor" operations should be multiplied by 1.7 in order to compare with Canada, while for "supervision" operations the factor 2.0 may be sufficiently accurate.

While these provisos may go some way to prevent the costs which follow from being entirely misleading, it must be remembered that no

Canadian organization could expect to carry on these operations now at the prices calculated, owing to the fact that they are also partly dependent upon other Swedish conditions, which we can not (at least at present) reproduce.

(b) Cutting and Hauling

The ordinary price for jobbers' contracts in the district first described was 60 öre per log delivered on the bank. For the size of log in question this probably corresponds to about $5.70 per M. B. M. in Canada.

(c) Marking Trees

This was estimated to cost 2 öre per tree in one case and .4 öre in another. (This discrepancy is probably due partly to less careful work and partly to larger timber combined with easier ground in the latter case.) These figures represent about 20 cents and about 4 cents respectively per M. B. M. in Canada.

(d) Seeding

This was given as 60 kronor per hectare in one case and 58 kronor per hectare in another, i. e., just over and just under $9 per acre respectively in Canada. (This includes cost of seed.)

(e) Planting

This cost 75 kronor per hectare in two places where inquiry was made, representing about $11.50 per acre in Canada. This was considered too high a price by one of the companies concerned, but female labor was scarce owing to competition by a local leather-working industry. (It does not include cost of plants.)

(f) Thinning

(These figures were obtained in Angermanland, and refer to the operations for raising soil temperature and releasing overcrowded stands.)

The average cost for removal of birch and thinning young conifers was 14 kronor per hectare. This represents about $2.57 per acre in Canada. A particular example which was shown me of thinning a dense spruce thicket to a density of 500 stems per acre had cost 30 kronor per hectare, corresponding to about $5.51 per acre in Canada. (N. B.—This stand was very similar to the usual Canadian balsam thicket.)

(g) Forestry Overhead

I was of course particularly anxious to find out the general cost of "forestry" as it is understood in Canada, i. e., divorced from some-

thing else that is called "operations." But it turned out that this question was one which the Swedes did not consider, and consequently they could give me no proper information. In the first place they realize that all forest operations are forestry, either good or bad; they do not distinguish between operations necessary to the bare making of logs as distinct from other operations necessary to the making of logs in a particular way and consequently their costs are not classified along these lines. And again the fact that the forestry departments are credited with the market price of their logs and are allowed a free hand within that price tends to obscure all such problems, the head office in particular not having an interest in the details. It was only with difficulty that I could make one of my informants grasp the idea of a cost of making logs apart from that of the attendant regenerative measures, and when he did so he gave me a rough estimate that would amount to about $2.30 per M. B. M. when corrected for Canadian prices. This figure covered sowing, planting, and cleaning, but not thinnings which could be sold; nor did it cover the marking of trees for final fellings nor any increased price to jobbers for operations conducted in a particular way rather than in another way that might have been cheaper.

Another informant thought that possibly two per cent of the company's profits might be returned to the forests, though this was in the nature of a guess rather than of an estimate.

(h) Summary

The foregoing facts may not take us very far, but at least one conclusion may be drawn from them with fair safety, namely, that even in Sweden forestry is not done for nothing. The cost of $5.50 per acre for thinning a spruce thicket, for instance, is a serious item, and even the average price of $2.57 per acre for all thinnings is not a bagatelle. Again, the fact that planting is constantly resorted to at a cost representing perhaps $14 per acre (including cost of plants) shows that the Swedes go to what we should consider great lengths in order to perpetuate their forests. The argument from the costs is thus the same as that from the conduct of the operations, namely, that the work is done properly, along normal lines, and that the necessary price is paid.

Other conditions no doubt make it easy for them to pay this necessary price (e. g., logs on the bank at $5.70 per M. B. M.) but it is important to recognize that a considerable expense is actually undertaken and that there is no question of obtaining favorable financial results by means of ingenious innovations or modifications of system.

(B) Application In Canada

I. DIRECT APPLICABILITY OF SWEDISH METHODS

Having seen in some detail what organizations and methods are adopted by Swedish forest-working companies we are now in a position to pass on to the question of how much, if any, of this experience can be made use of in our own operations, and of what other lessons can be drawn from it.

Now it must be already clear, from what has been said in the preceding sections, that in spite of the alleged similarity between Sweden and Canada the two countries are also dissimilar in many important respects. As these dissimilarities have only appeared incidentally, as it were, in the description of other matters, it will be worth while to recapitulate them here on their own account, and see whether they do not after all outweigh the undoubted points of natural resemblance, to which allusion was made in Part A, Section 1.

(a) The most important points of difference between the two countries probably fall under the following heads:

(1) Land Tenure. The companies own their lands in fee simple and are in no danger of losing them on the pretext of settlement or through any political jockeying. Consequently they are sure of securing any profit accruing through the expenditures that they make on improvements.

(2) Forest Law. The law enforces the regeneration of all cut-over land, thus making it necessary *for all alike* to practice what would be classed as "intensive forestry" in Canada. The difference between actually regenerating the ground, i. e., showing a concrete result that will satisfy a board of inspectors, and abiding by regulations which it is hoped may eventually achieve that end, is very great when it comes to actual operations.

(3) Fire. Fire does not have to be considered in Sweden. This is probably an even more important point than the freehold possession of land. But we must remember that the present immunity of Sweden from fire is only the recent result of a long campaign of forestry propaganda, such as has now begun in Canada, too.

(4) Labor Situation. The dense population and comparatively low wages, together with the fact that the villages from which the workers are drawn are scattered all through the forest and not situated 50 to 100 miles from the theatre of operations, combine to form an easy labor situation and to reduce all costs into which labor enters.

(The same facts have also helped to influence the fire situation favorably.)

(5) Technical Supervision. Sweden possesses large numbers of foresters who are thoroughly trained in the conduct of logging operations, and thus no difficulty is experienced in combining two functions which in Canada have to be divorced. At the same time the working classes start with the advantage of an excellent general education, and foremen who have in addition taken a course in forestry at the rangers' school are very plentiful and comparatively cheap. The facts that most Canadian companies have a few foresters somewhere in their organization and that a rangers' school has recently been started do not of course constitute a parallel to this situation in any way at all.

(6) The Scale of Operations. Areas are small, distances are short, and operations in general seem to be carried on on a much smaller scale than in Quebec. This, combined with the distribution of labor in the forest areas, tends to simplify logging and minimizes the need for great specialization in logging practice. It also makes planting and sowing possible, without which complete regeneration of a forest is hardly ever practicable; and facilitates inspection and control of all kinds to a very great extent.

(7) Products. The demand for forest products is more elastic than in Quebec, in that pulpwood as well as sawlogs is cut everywhere and the quantities of the two are proportioned to the capacity of the forest, and are not made to depend on the economic requirements of a mill of arbitrary size. Also in many places, though not everywhere, a local market for fuel and charcoal-wood makes early thinning and the removal of hardwoods profitable.

(8) Conditions for Silviculture. Owing to the absence of yellow birch and shade-bearing undergrowth, and the fact that the other birch species are present in smaller quantities and reproduce less vigorously than the paper birch of Quebec, a satisfactory natural regeneration of conifers is easier to obtain than it is in our own case.

(9) National Mentality. The Swede, whether in the capacity of shareholder, voter, forest laborer, farmer, or what not, regards it as axiomatic that the forests must be conserved and improved. This can not, unfortunately, be said with truth of Canada. It would be fair, in fact, to say that the Swedes are persuaded, whether rightly or wrongly, that it pays them to work their forests in the way they do; while the Canadians, so far from being similarly persuaded that it would pay them to adopt more intensive forestry methods, regard it (and perhaps

rightly) as an open question whether any considerable improvement in our present system of operating would be economically possible at all.

(b) Conditions Not Similar

In view of these facts, and remembering that the present vogue of Swedish forestry has arisen largely in the United States, where again different conditions apply, it is probably reasonable to conclude that the tendency has been to exaggerate the similarities and overlook the dissimilarities between Canada and Sweden, and consequently that we should not expect to be able to make any direct, immediate, or wholesale application of Swedish methods to our own operations or organization.

II. LINES OF APPROACH

(a) Trained Subordinates the Keynote of Success

But it must not be assumed on the strength of the conclusion drawn at the end of the last section that we have nothing to learn from Sweden. On the contrary, it would appear that a very important lesson emerges from what has been said so far.

As was stated in the introduction, I was particularly on the lookout for bold innovations in silvicultural practice, such as might be expected to cheapen the processes and make at least some sort of silviculture, though perhaps not the best, possible under unfavorable natural or economic conditions. But as has been stated above I found that no such "short cuts" existed; that the methods in use were the normal ones with which all foresters are familiar, and this even in the case of a company that could hardly afford to pay for their proper application. Swedish silviculture, in fact, like that of other countries, depends ultimately on the training and judgment of a bush-foreman who looks at and blazes every tree in the old-fashioned expensive manner, and no diameter-limits or other mechanical devices are employed to obtain a less perfect but much cheaper result. Yet it is not to be supposed that there are not bankrupt or embarrassed companies that would willingly adopt any such methods if they were practicable; and even the government forestry service might have been glad to employ them in the wild and distant Crown-forest areas of Lapland.

It is therefore reasonable to conclude, from the total absence under such circumstances of any means of "making the best of both worlds" in the manner suggested, that the search for any such means is certain to prove fruitless, and may be given up.

(b) Lessons to Learn

But this conclusion places a Canadian company in a dilemma. There are now two courses open to it, namely, to continue operations on existing lines, or to introduce improved methods with a view to ensuring a sustained or increasing yield. The first course is already discredited as being liable to undermine stability, so that only the second course would appear to remain open, with all its implications.

What then are the implications for a Canadian company of a policy of real progress in forestry, as far as Swedish experience suggests them? They can not all be foreseen in detail, but their most important features would appear to fall under the following heads:

(1) Fire and Land Tenure. Fire must be stopped and security of tenure of forest lands obtained. Though these conditions are put first, as being of absolutely paramount importance, it is not necessary to wait until they are fulfilled before those which follow are faced, as these latter raise problems which will require a long period for their solution, and preparations on the right lines should be begun at once.

(2) Forest Personnel. Logging operations must come into the hands of foresters, and the idea must be abandoned that logging is one thing and forestry another. This will not be achieved by attaching foresters to a logging staff in an advisory capacity nor by rashly entrusting logging operations to men who are unfitted to carry them out; it can only be done by ensuring that the *young* men who are from time to time taken in *at the bottom* of the logging organization shall be trained foresters and not, as they usually are at present, untrained persons to whom it happens to be convenient to offer a chance of making good. In this way a staff of assistant managers and eventually of managers could be built up to whom the idea of forestry was familiar, and who would be able to manage their areas of forest with a minimum of aid from specialists in exactly the same way as the Swedish "district foresters" have been described as doing.

And these remarks apply equally forcibly to the case of the subordinate staff. A district forester in Sweden without trained subordinates would be helpless, and it follows that if a real forestry personnel is to be built up the foreman and assistant foremen must also be provided for. This implies that the movement for rangers' schools already started by the government should be encouraged and expanded, and a real attempt made to fill all subordinate inspection posts with men who have received such a training.

(3) Labor must be brought nearer to all parts of the forest and kept there at all times of the year. How this can be achieved without raising worse difficulties (e. g., fire and colonization risks) than it is intended to solve, need not be discussed here. I wish simply to point out that until this condition is realized all silvicultural improvement work, depending as it does on individual judgment and absolutely requiring to be done on a small and individual scale, will remain exceedingly expensive and will in fact be hardly possible to carry out properly at whatever cost.

(4) Location of Timber Lands. A possible alternative to bringing the labor to the forests is to bring the forests to the labor, which also means bringing the forests nearer to the railways and so increasing the probability of being able to dispose of hardwoods and small produce, as good silviculture so insistently demands. The present tendency in Canada is to concentrate on remote localities on account of the decreased danger in which these are placed from colonization and fire. But if forestry on a scale sufficiently intensive to entail thinnings and the removal of hardwoods even in a fairly remote future is seriously envisaged, it might be very desirable to reconsider this policy; and conditions might even arise (e. g., a definite collapse of the cultivation of uneconomic farms) under which a company should prepare to buy up abandoned farm lands close to the means of export in preference to pinning its faith on wild and distant areas.

(5) Summary. In summary [1] it may be said that real progress in forestry practice is not likely to be attained by isolated measures and minor adjustments of the existing scheme of things, and that if such progress is desired it will be necessary to face the question of a complete reform, slow but fundamental, of that very scheme itself.

[1] I wish to acknowledge the kindness of Messrs. Price Bros. & Co. Ltd. in permitting me to publish these notes; and to take this opportunity of recording my gratitude to my hosts in Sweden for their unfailing helpfulness and hospitality. A. G.

PREDICTING THE SECOND CUT IN NATIONAL FOREST MANAGEMENT PLANS

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The need for simple management plans in the administration of the National Forests constantly leads to the quest for a method of determining yield in selection stands, and particularly for a method of predicting the volume that will be available at the time of a second cutting perhaps 30 years after partial removal of the original natural stand. Great refinement in forecasting yield, if theoretically possible, would be inconsistent with the purpose of the plan, and the degree of accuracy of the other basic data entering into it. Such plans serve to orient the forest administrator and prevent overcutting until accurate data accrue from reconnaissance and yield studies.

A typical situation exists in the Sierra Nevada Mountains of California where the prevailing practice is to reserve 20 per cent or more of the original merchantable stand to supply seed for completion of restocking or insure new reproduction in case of destruction of advance growth by fire, to secure the benefits of stimulated growth due to thinning and to furnish a quantity of relatively valuable larger timber for the second operation. The residual stands are very uneven-aged, irregular in distribution and ordinarily composed of from two to five species.

Yield tables, when such are available can hardly be applied under existing conditions. None of the various suggested methods of applying normal yield tables derived from even-aged stands to selection forests have been generally acceptable. Possibly they have not been given proper trial because of their apparent complexity, and the difficulty of gauging the errors involved in the technique and in some of the necessary assumptions by which discount factors are derived. Professor Chapman (3-7) [1] has done more along this line than any other American investigator. Since the age classes in selection forests can not easily be determined, these are usually approximated by correlating age with diameter, through the medium of average diameter growth curves. The proportionate area occupied by each derived age class is then determined by mapping projections of the crown areas or by use of a crown area—basal area ratio in connection with stand tables. In selection stands the

[1] Numbers in parentheses refer to "References" on page 790.

correlation of age with diameter is rather general and the projection of the crown base is not a true index of the soil area occupied.

Apparently the most practical suggestion for approximating the second cut is to predict the growth of reserved trees represented in stand tables derived from sample markings prior to cutting or from inventory cruises of cut-over land permitting site class delineation or other subdivision into units with uniform conditions. According to Fernow (9), this method was taught by the German, Oettelt, in 1746, was adopted by the French and later used by the Indian Forest Department as a preliminary step to better methods. The idea appears in several of the earlier working plans made in this country, notably that for Adirondack spruce by Graves (10) in 1899. The present modification has recently been used in several working plans in California. The natural inference is that we are still taking our preliminary steps.

This method of growth prediction avoids the necessity of attempting to determine the age class—area relationship or the degree to which stocking will approach completeness at some future time. The object is not to estimate the total volume that will be present in a given time, but only what will be available for cutting in a relatively short time. The trees which will be merchantable for a second cutting are already in sight and can be selected with a fair degree of certainty. The danger in attempting to correlate growth with age through the medium of diameter is lessened by restricting the size of the diameter classes and by eliminating all but the dominant and codominant trees which will form more than 90 per cent of the second cut.

There are two available sources of data for such predictions of growth, increment borings and continuous records from permanent sample plots on cut-over land. Several sample plots have been under observation for fifteen years and have furnished valuable information on rates of growth of different tree types, annual losses, etc. For longer growth records the increment borer must be used. Some of the earlier private cuttings were effectually similar to present national forest areas in percentage removed and character of the remaining trees. The thrifty young trees left because unmerchantable at that time, are the type now deliberately selected for reservation. Private cuttings furnish the longest records of growth since the first national forest cuttings were not made until 1905. Unfortunately, however, few such private cuttings are to be found where cutting practice approximated what will prevail under management and where subsequent fires or culling has not rendered the areas unfit as sources of data.

Material for the white fir diameter prediction curves presented here for illustration, was obtained from an area cut over 42 years ago in the old Soquel operation on the San Joaquin River drainage. Cores were taken with an increment borer, and the diameters measured at breast height, for the trees which would be merchantable if another cutting were made today. These are essentially the trees which were dominant and codominant, or completely released at the time of cutting. By subtracting from the present diameters the growth since the date of cutting, the approximate diameters at the time of cutting were determined and the cores arranged on this basis in 2-inch classes. Intermediate measurements at 5-year intervals gave the progress of growth of the actual wood. Increment borings, of course, give no record of the development of the bark. Suitable data were available for a curve of bark thickness on diameter, permitting correction of the diameters derived from the increment cores. The final curves were then arranged in a series representing diameters at breast height for a period of fifty years after cutting, as in Figure 1. One or two curves of the series were found to have a different pitch from those adjacent, due to the inclusion of trees which grew more slowly or more rapidly than the average. These were arbitrarily harmonized with the others. After correction for bark thickness it was necessary to adjust slightly some of the curves to make them coincide with the even 2-inch intervals at the point of origin, or year of cutting.

Height-diameter curves were constructed from measurements on cut-over areas similar in character to those on which the increment cores were taken. Ordinary volume tables could then be applied.

For convenience the average heights attained by trees which started in the various diameter classes at the time of cutting may be determined from the height-diameter curve for each 10-year interval and written in on the diameter prediction curves. If values for intervening years are not desired, or a standard cutting cycle is adopted, the logical suggestion is to go a step farther and tabulate the volumes themselves in the form of a multiple volume table for the desired interval after the first cutting.

Where the prediction of growth is to be based on inventories of cut-over land giving the number of dominant and codominant trees in each 2-inch class which will probably survive and be merchantable at the time of the proposed second cut, it is only necessary to make corrections to the stand tables for normal losses and for thrifty trees which will enter the lower size classes during the first decade after logging. Cor-

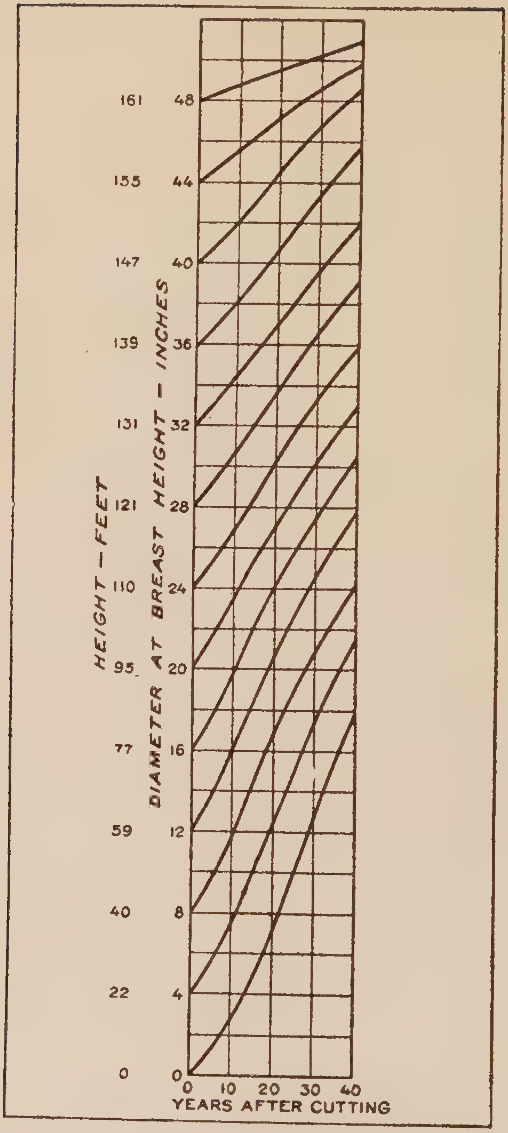

FIG. 1, DIAMETER GROWTH PREDICTION CURVES
WHITE FIR (A. concolor)
Basis 155 dominant and codominant
trees released by cutting in 1882
Site I, Sierra N.F. California

rections for losses are based on the records of the sample plots previously mentioned. Additions to the stand tables for trees which will become merchantable by the time of the second cut, but were below the limits of the stand tables at the time of logging, are also made on the basis of the sample plot records. Losses and increases occurring after the first decade are ignored. Corrections for unusual later changes may be made when the plans are revised if such become evident.

Where the growth prediction is to be based on sample markings prior to cutting, the stand tables should include only the dominant and codominant trees which inspection indicates will be merchantable for the second cutting. In this case correction must be made for immediate losses during logging and slash disposal, in addition to correction for subsequent changes during the first decade. Logging damage may materially reduce the second cut. It varies widely, depending upon the kind of logging, the density of the stand, topography, and other factors. At present the only basis for gauging losses from power logging are isolated studies, recently completed, by no means covering the field.

Obvious objections both in theory and application may be raised to such a method of yield calculation. Are these serious enough to render predictions valueless, or is there a better method?

As Chapman points out (6) there is a possibility of error in the use of average height-diameter curves as a substitute for true height growth curves. Such an expedient, however, is deemed preferable to complete disregard of the height factor, particularly since the error involved is less serious in selection forests than elsewhere. Data are now being collected from old cuttings for height growth prediction curves to replace the height-diameter curves.

It is probable that the acceleration of cross sectional growth after thinning is not uniform in different parts of the stem and that increment borings at breast height may give erroneous indications of volume growth. If such changes in stem form are caused, in part at least, by changed stresses due to exposure to wind and displacement of the center of gravity after cutting, it seems reasonable that with readjustment of the crown balance and restoration of the crown canopy, the normal stem form would be resumed. Errors resulting from the use of height-diameter curves would be greater for short than for long periods.

Another source of possible error exists in the method of correcting diameter growth curves for changes in bark thickness. Some recent investigation by Bruce leads him to believe that bark thickness varies with height almost as much as with diameter.

There are, of course, limitations in the use of this method of growth predictions aside from questions as to the correctness of the theories involved. Experience and a thorough knowledge of tree characteristics are necessary for the preparation of suitable stand tables. The effects of logging damage and subsequent losses can only be roughly gauged until a fund of data is available on which to base experience tables of tree mortality. The influence of advance reproduction, not included in the stand tables, affords possibilities of errors which will increase, rather than lower, the estimated yield. Many other obvious difficulties always present themselves in any attempt to apply growth figures obtained in one stand to others never exactly similar.

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SUGGESTIONS TO BEGINNERS ON CUTTING AND MOUNTING WOOD SECTIONS FOR MICROSCOPIC EXAMINATION*

By James L. Averell

The making of microscope slides of woody tissue may be divided into a series of progressive steps, namely: preparing the wood blocks, cutting, staining, and mounting. The mention of each step brings to the experienced worker a mental picture of just how he would go about each one. No such picture comes to the help of the novice who is struggling with his technique. If he has no experienced technician at hand for guidance, many hours are wasted in developing methods of procedure already well proven. Writers on this subject often fail to expand sufficiently on the axioms they give to permit students to follow. It is this lack of plain-spoken detail, important to the beginner yet so consistently omitted in microtechnique literature, which has prompted this paper.

In collecting the material and preparing the wood blocks, the following points should be kept in mind. Be sure each block is representative of what the slide is to show. If the slide is to illustrate typical structure of say, western yellow pine wood, be careful to avoid pieces with very fine ring growth or such rapid growth that an entire annual ring width will not be included in the cross section. Do not use pitchy pieces, compression wood ("Rotholz") with its abnormal thick-walled cells, or wood that has been abused in the kiln. When typical average wood structure is desired, the material should not be cut closer than two inches from the center of the tree, nor from branches or roots. In certain species, resin deposits, tyloses and infiltrations of gums and oils are very frequent in the heart wood, making features such as pits and starch grains difficult to see. This can be largely overcome by cutting the blocks from the sapwood of these species.

In cutting out the block, about one-half inch cube, make each cut as nearly true to the radial, tangential and cross section as possible. It is much easier to do this when the block is dry than after it has become "water-logged" in glycerine and alcohol, or darkened in appearance, following its treatment with hydrofluoric acid. To keep a record of the blocks, each one must be numbered in some way. A system of

*Contribution from the Yale School of Forestry.

nicks cut in a corner, or Roman numerals cut on a side, may be worked out. Numbers stamped on an end with steel dies will stay in and be legible if the cross section is smoothed off with a sharp knife so that a clear impression is made.

The blocks should be treated with hydrofluoric acid. This is not essential if green, unseasoned wood is used. Nevertheless, a short period in the acid will improve its sectioning. A bottle of commercial (full strength) acid may be used over and over again for soaking the blocks. Chemically pure acid is too strong and must be diluted with water to 30 or 40 per cent. strength. To permit the acid to enter all the cells in the block of seasoned wood, the air must be removed from the lumena (cell interiors). This is done by boiling the blocks in water. Periodic changing to cold water and then back to the boiling water, with sufficient time in each temperature bath to allow the interior of the wood to be affected, helps bring about the displacement of the air by water. If a vacuum pump (aspirator) is available, the time may be further shortened in causing the blocks to sink. At the Madison Laboratory it has been found that equally good results are obtained by boiling the blocks till heated through and then transferring them to the acid while hot; the acid is thus drawn into the wood. This latter method has the further advantage in that the danger is lessened of removing the infiltrated gums and oils which in some woods are of diagnostic importance.

Hydrofluoric acid is well known as the chemical agent used in etching. It is also commonly used for preparing blocks of wood for sectioning. The acid dissolves out some of the mineral matter in the wood, thus making the cutting much easier. According to Brown, tracheids and fibers have a siliceous skeleton within the secondary wall. He believes that he can thus explain the small longitudinal shrinkage of wood in contrast to the relatively large transverse shrinkage, and also make clear the softening effect of hydrofluoric acid. The nature of the acid is such that it has no apparent effect on any gums, resins, or crystals of calcium oxalate or calcium carbonate in the wood. Further, it does not seem to change the cellular structure of the wood, so that hydrofluoric acid may safely be used on woods to be sectioned for structural study.

Woods of soft character require less time in the acid than hard woods. Soft pines, poplars and the like, should be ready in one to two weeks, oak in three weeks, while certain extremely hard tropical

woods are said to take five months. The blocks are tested with a razor blade and when they cut smoothly and easily, are removed from the acid and washed thoroughly in running water. While working with hydrofluoric acid, rubber gloves prove to be cheap and efficient insurance against acid burns. Sooner or later, one grows careless with this very active acid, and the burns it gives are anything but pleasant. The wax bottle containing the acid should be kept away from metal and glass, as any escaping fumes quickly eat into them. Microscopes are quickly ruined by having the lenses etched with the fumes from this acid.

The washing of the blocks is easily accomplished in the following arrangement: Fill a glass jar with water, put blocks in, tie a layer of cheesecloth over the mouth of the jar, and insert a rubber hose from a faucet through the cheesecloth to the bottom of the jar. When the faucet is turned on, a circulatory system is set up in the jar which should be allowed to run for at least 48 hours to properly wash out the acid. Care must be taken that all the acid has been leached out from the center of the block, leaving the blocks in standing water which is changed periodically for another 48 hours.

The blocks are then put in a half-and-half mixture of glycerine and alcohol, the latter of about 30 to 50 per cent. concentration. This will keep them in good condition for a long time. A recent experience throws some light on this point. Blocks of thirty-six important woods of the United States were stored in the glycerine-alcohol solution for two and a half years. On being taken from this solution, they were found to be in excellent condition for cutting. The only detrimental effect their long storage seemed to have had was in such soft woods as Sitka spruce and red pine where a softening of the thin walled cells had occurred (such as the ray parenchyma cells and the epithelial cells). This made sectioning difficult, for the cross section would fall apart at each medullary ray and the resin ducts would be but a hole in the net work of tracheids, with no definite lining of thin walled cells. However, by making a cross sectional cut through the center of the block (with a safety razor blade) and starting sectioning from this fresh surface, the softening effect of long storage was largely overcome. A long stay in a solution containing glycerine is thought by some to make staining difficult, especially with Delafield's haematoxylin and analin blue.

The hydrofluoric acid method is not the only one for softening woody tissue, though it is the one most commonly used. The acetone method of softening wood, as described by Williamson, is also very satisfactory according to some technicians.

A Jung-Thoma type of sliding microtome (or one of its modifications) is excellent for cutting woody tissue. Its steel bearing surfaces may be oiled with any good grade of light machine oil, but it will be found that paraffin oil is by far the best. Clean the bearing surfaces with xylol, benzine or gasoline, dry them carefully and apply the special paraffin oil supplied by any firm dealing in microtomes. A smoothly working machine is a great help if any number of sections are to be made.

A good knife is the straight type of microtome blade, 6.75 inches long and 1.4 inches wide, one side flat and the upper one concave and provided with a detachable handle used when sharpening. Another addition sometimes used when sharpening the knife, is a three-quarter round cylinder of spring steel which slips over the back. This gives a slight tilt to the blade while honing, which increases the bevel of the edge. Since very good results are obtained without it, its use seems to be optional. Knives with both upper and lower sides concave are not satisfactory. Those with both sides flat work well, but need the spring steel cylinder for honing.

The secret of making good microscope slides is to have a smooth, sharp edge on the microtome knife. It is best to allow some firm that deals in fine instruments (A. Lietz; Bausch & Lomb; etc.) to grind the knife occasionally. This machine grinding puts a much-used knife back in working order again by establishing a new bevel. Honing and stropping to a good cutting edge should not take over half an hour. If more time than this is required, either the technique is imperfect or the knife needs grinding. A knife that had just been ground was used to cut some 2,100 sections of North American woods and on their completion, was not in any great need of machine grinding.

The cutting edge must be smooth as well as sharp. Under the low power of the microscope, it should appear as a straight line. Any nicks in this straight line, even though the naked eye can not see them, will be sure to leave their path across the section. The cross section is particularly sensitive to any such nicks. The barber's razor-edge is a good example of a cutting edge that is sharp but *not* perfectly smooth. The microscopic saw-teeth cut the hair. However, a microtome knife

is no place for such a "razor-edge." When sharp, the microtome knife will also cut a hair and if accompanied by smoothness, will cut good wood sections, as well.

The yellow Belgian hone used with soap and water (Ivory, Palmolive, etc.) is the first step in honing. (Half and half glycerine and 70 per cent. alcohol may also be used in place of soap and water.) This step may often be omitted if the edge has not been used much since the last honing. The second step is the blue-green water hone rubbed with the accompanying small piece of softer stone to make a grinding paste. Hones should be at least two inches wide and about eight inches long.

Honing is a job requiring utmost care and is the place where most failures in successful knife sharpening are hidden. The operator often believes he is using care but has not risen to that degree of care which means success. Less than a dozen perfect strokes on each side of a blade on each stone should put a knife back into condition again. A number of perfect strokes and one final stroke in which the cutting edge is not quite flat against the stone, will so affect the edge that sharpening will have to be done over again. Each stroke, therefore, must be individually perfect.

The way to insure the cutting edge remaining flat at all times is to use two hands on the knife. Be sure the stone cannot wobble. Take the knife by the handle with one hand and put the finger tips of the other hand on top of the blade to keep it bearing flat on the stone. A slight horizontal rotary motion helps keep the blade flat and more effect per stroke is accomplished. No pressure other than that required to feel the solidity of the two rubbing surfaces of steel and stone is necessary. The care is needed, not in keeping the knife from tipping toward the cutting edge or toward the back, but in keeping it from tipping toward either end. Only an infinitely small amount of such tipping is necessary to put that "razor-edge" on the knife. This is why one-handed, straight strokes do not succeed with a microtome knife, for it is not possible to keep the edge always absolutely flat. Each stroke should proceed with the rotary motion up the stone and off the end. The one-handed method is usually accompanied by flipping the knife on the stone to its other side, which is not much help in keeping a necessary true, flat surface on the stone. Several strokes may be made on one side and then the handle shifted to the other hand and the other side of the knife honed. Always have the cutting edge lead in the general direction the knife is traveling up the stone—never the

back first, as in stropping. When the honing job is done, the edge should be a straight line under the low power of the microscope. Don't hope to rub out nicks on the strop, for improper honing can not be corrected even by endless stropping.

A good strop is a high grade razor strop, comprised of two strips, joined by a swivel hook clasp at one end, either all of leather or of canvas and leather. The important point is to have a final "hard shell" leather surface. A piece of softer leather or prepared canvas serves as an intermediate step from the hones. The edge that comes from the hones is smooth but not sufficiently sharp to cut thin sections. Stropping increases this sharpness. Twenty to thirty complete strokes (up and back) on each strip should make the edge so that it will cut a good section. The strop must be pulled good and tight to prevent undue sagging. Only a slight pressure to insure a firm stroke is necessary. Slapping the blade up and down a sagging strop as a barber does, only rounds off the edge on the wide, heavy microtome knife. Much less care, however, is necessary in stropping than in honing, for the swivel hook takes care of tipping. Often this edge will cut twenty good cross sections without attention. Before the longitudinal sections are started on, a dozen complete strokes on the "hard shell" surface will renew the edge. The more times the strop is used, the better the edge becomes until finally the continued stropping rounds the cutting edge and honing is necessary to take the "checks" off the edge. This stage is known to be reached when stropping no longer revives the cutting power.

Strops mounted on wood, in this particular instance, have not given such good results. Usually preparations have to be put on such strops or they will wear rough. The preparations do not give the clean, hard surface that a "hard shell" leather presents. Also, a slight tilt toward the cutting edge is necessary to insure the cutting edge getting the benefit of the stropping. Tipping toward the ends of the knife must again be guarded against, as in honing.

The sharpened knife is set firmly in the microtome with the set-screw clamp. The vertical angle of the knife is kept at the mark "5" on the Spence modification of the Jung-Thoma machine (about five to ten-degree angle between the flat lower side of the knife and horizontal). The more of the cutting edge used at one time to cut a section, the thinner and more perfect the section can be made. However, when these very acute horizontal angles of the knife are used, the cross section

often has a tendency to curl up, especially with hard pieces of wood. It will curl badly if the medullary rays parallel the cutting edge of the knife. Even though held flat by a brush during cutting, the sections will curl right up, with the rays remaining perfectly straight, when put in alcohol or water. This can be largely overcome by turning the block until the rays run at right angles to the cutting edge. Another aid to prevent curling of sections is the use of a form of nitrocellulose, either cellodin or collodion, which will form a thin film over the section to be cut. Collodion, sold under the name of "New Skin" at drug stores, may be used. Most frequently, however, the sections can be held flat by means of a camel hair brush when cutting.

After clamping the block of wood in the object carrier, the knife is adjusted, its upper surface flooded with 40 per cent. alcohol applied with a camel hair brush, and several sections cut 30-40 microns thick (the presence of any torn cells due to nicks in the cutting edge can be plainly foretold by their streaks across the block surface). If these sections appear under the microscope to be generally good, raise the block 10 to 12 μ (μ = 1 micron = 1/1000 millimeter) with the racket next to the object carrier, paint the end of the block with collodion and allow it to dry. If not allowed to dry (it takes about a minute) the section will curl anyway when put in alcohol or ether solutions. Then flood the knife and hold the section lightly with the brush, while the knife slips under and cuts it from the block. It can then be removed from the knife with the brush, or a section lifter, to the 40 per cent. alcohol solution. The wood block should not protrude above the metal clamp more than a tenth of an inch, or difficulty will be had in keeping it rigid. If the knife jumps when it hits the wood, either the block has need of further treatment in the acid, or the set-screws or block are not firm, or the vertical angle of the knife is too small. Collodion is dispensed with in the sections showing no tendency to curl.

Sections treated with collodion must be put in half and half ether and absolute alcohol to dissolve it out, before they can be stained and mounted. Straight alcohol will not affect the collodion. After half an hour in several changes of ether and alcohol, wash the sections in 95 per cent. alcohol and transfer to the 40 per cent. alcohol solution, where they are ready to stain or to mount direct.

Often only those woods are stained which have no distinct natural color when sectioned. In the longitudinal sections of the pale colored woods, it is difficult to tell the presence of cell walls between the parallel

rows of cut walls unless stained or unless the wall have pits. However, in the Yale collection of slides, practically none are stained, as it is thought the detailed structures are clearer if the sections are left uncolored. Most of the hardwoods have a marked natural color of their own.

For certain work, nicely stained sections are a great aid. They may be single stained or double stained. In the latter case, two colors are used, each staining a chemically or physically different tissue.

In anatomical work, safranin is acknowledged the most generally useful stain. It is easy to make, easy to use, and is permanent. It is an analin dye which stains lignified, suberized, and cutinized structures red, while it can be washed out of cellulose tissues. To color the cellulose elements, either Delafield's haematoxylin, Haidenhain's iron-alum haematoxylin, or an alcoholic solution of analin blue is commonly used. Any number of possible combinations may be found, but these are recommended.

Delafield's is the classic stain of plant histologists for cellulose tissue. It permanently stains the cellulose walls in wood tissue, a deep purple. A general schedule for its use may be found in Chamberlain's book, "Methods in Plant Histology."

Haidenhain's iron-alum haematoxylin also gives a permanent stain and its use is especially recommended by several microtechnicians for woody tissues. They claim it is less troublesome to use than Delafield's. On the other hand, Delafield's solution of haematoxylin will keep for a number of years, while this one will spoil in a short time.

Anilin blue is an easy stain to use for cellulose tissues. It is permanent, differentiates well and is very pretty in combination with the safranin.

Directions for mixing and using all these stains are given in Chamberlain. However, it will be found that good staining requires considerable practice. The time necessary for each step differs with the species, thickness of section and direction of cut (cross, tangential or radial). A good section may easily be ruined by poor staining.

The three sections of each wood can be mounted under one square cover-glass. Glycerine jelly is used instead of balsam. This medium is employed to permanently mount all slides in the Yale collection. It has every advantage of balsam as to clearness, permanency, resistance to rough handling, etc., and in addition, is much faster to use. No time consuming baths of varying degrees of alcohol and xylol are neces-

sary, as in using balsam. Sections may be mounted directly from alcohol or water in glycerine jelly. This substance is not to be confused with the old glycerine mounts which had to be perfectly sealed.

The jelly is removed in as large chunks as convenient from the bottle to a clean glass slide where it can be cut up into smaller pieces. A piece with the volume of a block ⅛ inch square and 3/16 inch long is sufficient for one slide. It is better to have too much than too little as the excess can be squeezed out. A scalpel and a dissecting needle are convenient to work with on the jelly.

The sections are arranged on the slide from the 40 per cent alcohol solution they were cut in. The block of glycerine is placed in the midst of the three sections and the slide held by a bent wire test-tube holder or similar device over a Bunsen burner flame. A full minute at 4½ inches above a 2½-inch flame is required to melt the block of jelly. Constant watch is necessary to insure the moist condition of the sections not being lost while the jelly is heating to melting temperature. Here the advantage of using somewhat less than a 50 per cent solution of alcohol is seen, for if the sections are moist when put over the flame, the lower percentage of alcohol reduces the rate of evaporation and they will not dry out before the jelly melts. As soon as any liquid jelly forms, it can be made to run and cover the sections by tipping the slide. Once they are covered with jelly, the danger of drying out is past. To add more alcohol after the heating process is well under way is to invite air bubbles, a trick this medium indulges in at the least provocation. Keeping the jelly in fairly solid chunks, rather than chewing it up in fine pieces when extracting from the bottle, is another way to avoid air bubbles. When the jelly is finally melted, it rests on top of the sections as a globule, ready for the addition of a cover-glass. If any bubbles are in the globule, they will be floating at the top and can be scraped off with the cover-glass first. Lower the cover-glass slowly and gently, watching for air bubbles. With the cover-glass down, the sections may be arranged in position with a narrow piece of broken cover-glass moistened in the alcohol. Then the glass is pressed down and the excess jelly squeezed out. If this final squeezing is not done, when the slide cools one can move the cover-glass slightly, though not permanently, for it will return to its original position. But if care is taken to see that only a thin layer of jelly remains under the glass, it will be firm and hard in a few minutes after being taken from the flame. This final pressure is important also to insure the sections being perfectly flat, a

necessity if the slide is ever to be used for photomicrography. The excess can be scraped off with a knife when cool. By running a border of high-grade varnish around the edge of the cover-glass, a finished and durable job is made. The completed slide can then be cleaned with alcohol.

Another mounting medium, one that was popular fifty years ago and has since dropped out of general use, is Farrant's Medium—a solution of gum arabic and glycerine. This material was found to be too severe on delicate tissues. But for woody tissue, it seems to work well. It is used cold, a drop from a glass rod being put on the section and a cover-glass lowered carefully over it. After 48 hours' exposure to the air, the liquid around the edge hardens. The result is a clear, durable slide. Some slides made three years ago, mounted in this medium, show no signs of deterioration with age.

Farrant's Medium has the advantage over glycerine jelly in that no heating is required, which reduces the time necessary to make a slide and eliminates the hazard of drying the section while melting the jelly. The disadvantage, however, is the time it requires to harden to make handling safe. The gum arabic under the center portion of the cover-glass probably never does harden. Another disadvantage is its tendency to form minute air bubbles when placed on the section. They are more difficult to get rid of than those in glycerine jelly.

The materials mentioned as being used in this work may be purchased at various places. For convenience of the new student the following are mentioned:

At any barbers' supply store—the leather strop with a hard-shell surface.

At the Empire Laboratory Supply Co., 218 East 37th Street, New York City, Cover-glasses—½ oz. (about 70) size No. 1, ⅞ inch square. Slides—1x3 inch—(about 60 in a box).

At Eimer & Amend (chemical supply house), New York City. All chemicals and prepared mounting mediums (in ½ oz. bottles).

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FORESTRY AT THE INTERNATIONAL CONGRESS OF PLANT SCIENCES

By Ralph S. Hosmer
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The international Congress of Plant Sciences held at Ithaca, New York, U. S. A., from August 16 to 23, 1926, will be remembered as a notable event in the annals of botany. Approximately 1,000 delegates were in attendance, representing many countries and a wide range of the interests having to do with plant life. Not only were the meetings marked by the presentation of notable papers, but what is perhaps quite as important, opportunity was afforded to establish or re-establish personal contacts among investigators and educators whereby the way is prepared for the co-ordinated and sympathetic advance of the plant sciences. No similar gathering of even approximately like scope had been held since the Third International Botanical Congress at Brussels in 1910. The meeting at Ithaca afforded a practical demonstration that the scientists of the world were once more on common ground. But this Congress, technically the fourth in the series, differed from its predecessors in that it was made up of all divisions of the broad field of botany. It fulfilled the intention of bringing together leaders whose work lies in applied science as well as those whose activities are in pure research.

Further, this Congress confined itself solely to the consideration of fundamental contributions to the research and educational aspects of plant science in its several branches. By a self-denying ordinance, it excluded legislation on regulatory matters, such as nomenclatorial rules, although providing adequate opportunity for discussion of these matters in order that a better understanding might be reached for definite action at subsequent international congresses.

The organization of the Congress consisted of a President, Dr. Liberty Hyde Bailey of Ithaca, New York; a board of fifteen Honorary Chairmen, representing as many nations; a Vice-Chairman, Prof. John Merle Coulter of the Boyce Thompson Institute for Plant Research; a General Secretary, Dr. B. M. Duggar of Washington, D. C.; and a Treasurer, Dr. G. T. Moore of St. Louis, Missouri; together with an Executive Committee and Committees on Program and on local arrangements.

The Congress itself was divided into thirteen sections, as follows: Agronomy; Bacteriology; Cytology; Morphology; Histology and Paleobotany; Ecology; Forestry; Genetics; Horticulture; Physiology; Pathology; Pharmacognosy and Pharmaceutical Botany; Taxomony; and Mycology.

The technical papers were presented at four half-day sessions, when each section met independently; these morning meetings being accompanied by symposiums and round tables on certain afternoons, and supplemented by informal meetings of groups when the topics under consideration demanded furthur discussion. Two evenings of the week and two brief noon sessions were devoted to meetings of the Congress as a whole. Two afternoons of the week and all of Saturday were given over to excursions to points of interest in the vicinity of Ithaca.

The headquarters of the Congress were in Willard Straight Hall, the recently completed Cornell Student Union. Here opportunity was had for social contacts, especially at the tea hour. Different groups also got together evenings for dinners and smokers. The Congress throughout was marked by a spirit of informality which helped contribute to its success. Barring a succession of showery days, it is only to be regretted that a larger number of Europeans could not have found it possible to come to the United States for this Congress. Actually about 100 of the 1,000 delegates were from abroad, but in personnel and in distribution by countries, these persons were representative of a wide range of botanical interest.

The Forest Section of the Congress drew together, in its make-up and in the papers presented, a group that emphasized the international character of Forestry. The Chairman of the Section was Prof. Dr. Tor Jonson of the Skogshögskolan, Stockholm, Sweden; the Vice-Chairman was Dr. C. D. Howe, Dean of the Faculty of Forestry, University of Toronto, Toronto, Canada. The Secretary and Ass't Secretary were, respectively, Profs. Ralph S. Hosmer and J. Nelson Spaeth of the Dept. of Forestry, Cornell University. It may also be noted that two of the fifteen Honorary Chairmen of the Congress were foresters: Prof. A. K. Cajander of Helsingfors, Finland, and Prof. A. Serpieri of Florence, Italy. Neither could attend in person, but both sent papers which were read and discussed.

The general topic for consideration before the Forestry Section was: "The Scientific Foundation of Forestry as exemplified by Forest Experiment Station Work." Following is a list of the technical papers making up the Forestry Program:

*Prof. A. Serpieri and Prof. A. Pavari, Florence, Italy.—Forest experimentation as a scientific basis of silviculture, with special reference to Italy.

Dean C. D. Howe, Toronto, Canada.—Some aspects of forest investigations work in Canada.

Prof. James W. Toumey, Yale University, New Haven, Conn.—Initial root habit in American trees and its bearing on regeneration.

*Prof. A. K. Cajander, Helsingfors, Finland.—The scientific foundation of forestry as exemplified chiefly by forest research work in Finland.

Prof. Dr. Tor Jonson, Stockholm, Sweden.—Methods and means of judging standing trees and the calculation of volume, yield and growth.

Raphael Zon, Director, Lake States Forest Expt. Station, St. Paul, Minnesota.—The role of the forests in the circulation of water on the earth's surface.

*Dr. Sven Petrini, Stockholm, Sweden.—Thinning and increment.

*A. Rodger, Esq., Dehra Dun, India.—The improvement and development of the forests of India by means of scientific research.

E. N. Munns, U. S. Forest Service, Washington, D. C.—The future of forest experiment station development.

On Wednesday, Aug. 18, the Forestry Section had a joint meeting with the Ecology Section when papers were presented by Dr. A. Palmgren of Finland, (read by Prof. A. G. Tansley) Prof. Eduard Rübel of Zurich, Switzerland; Prof. G. E. Du Rietz of Upsala, Sweden; and Profs. J. W. Toumey and G. E. Nichols of Yale University, New Haven, Connecticut. An early adjournment of the Forestry Section on Friday permitted the foresters also to hear a paper by Prof. Tansley: "Succession: The concept and its values." There was adequate discussion of all the papers read before the Forestry Section.

In the Forestry Section Symposium on "International Forest Bibliography," the discussion turned on the proposals made at a conference held at Zurich in April 1926, for a system of classification put forward by a committee of the International Association of Forest Experiment Stations consisting of Dr. Philip Flury of Switzerland and Prof. A. Oppermann of Denmark, together with recommendations of a similar nature made by a committee of the Society of American Foresters. At the conclusion of a lengthy discussion the following resolution was adopted as expressing the sense of the meeting:

*These papers were read by others in the absence of the authors.

"RESOLVED: That it is the sense of the Forestry Section of the International Congress of Plant Sciences that it is in favor of seeing an International Forest Bibliographic Commission organized, and that those nations having a forestry organization be invited to establish a national forestry commission, the chairman of which shall be a member of the International Forest Bibliographic Commission: that the International Forest Bibliographic Commission have an executive committee of five (5) members, the duty of which shall be to decide what organization shall issue a bibliography and to devise means for carrying on the work."

The afternoon of August 20 was devoted to a consideration of plans for bringing about closer international relations between foresters, particularly through the agency of the International Association of Forest Experiment Stations. Mr. S. T. Dana, President of the Society of American Foresters and leader of the American Delegation at the World Congress of Forestry held at Rome in May, 1926, who had returned from Europe only a couple of days before this meeting, told interestingly of the proceedings of that Congress, and especially of the parts played by the British and American delegations there present.

Apropos the announcement that plans were under way for a meeting of the International Association of Forest Experiment Stations at Stockholm in 1929, the hope was expressed by several speakers that this action may result in the re-organization of that association on a permanent and adequate basis, and a resolution to that effect was adopted as the sense of the Section.

The announcement having been made of the acceptance of the invitation of the British Delegation that the Fifth Botanical Congress be held at London in 1930, someone expressed the hope that a Forestry Section might be included, as it had been at this meeting. This suggestion was heartily endorsed as offering another opportunity for the interchange of ideas on problems of common interest and for the further development of the friendly relations that already are so happy a characteristic of the profession of Forestry the world over.

In the week following the Congress, a party made up of members of the Forestry Section made a three-day excursion by automobile through the Adirondack Forest of Northern New York. This gave an opportunity for those who took the trip to see a typical section of the "Northern Forest," as differentiated from the "Central Hardwoods Forest" in which lies the region about Ithaca.

Final arrangements for the publication of the Proceedings of the Congress had not been completed when this statement was prepared, but it is confidently expected that all the papers read before the several sections will be published in full. The resulting book will be sent to all who were enrolled as members of the Congress, and sold at about cost price to any one else interested. Announcements of the issue of the Proceedings will appear in due season in the leading scientific journals of the several countries that participated in the Congress.

REVIEWS

"Factors Determining Natural Reproduction of Longleaf Pine on Cut-over Lands in LaSalle Parish, Louisiana." By H. H. Chapman, Yale University, School of Forestry, Bulletin No. 16.

This publication is decidedly timely and welcome, being the first to present results based on a systematic and comprehensive study of natural reproduction of longleaf pine. Its object is to investigate factors affecting the establishment and survival of natural reproduction and to determine the extent of their influence. Many very striking and interesting results were brought out.

The area on which the study was made is located near the northern limit of the longleaf pine belt, and is hardly typical of the great bulk of the type, but the relationships observed will probably apply in varying degrees to the region as a whole.

Chapman takes up first the study of seed trees and seed production. Conclusions are based on observations made on 1,034 trees 9 inches and over in diameter, left as unmerchantable on an area of 91.8 acres, cut over in 1904. The figure for loss of seed trees, 2.83 per cent or approximately 1/3 of 1 per cent per year, since 1917, 13 years after cutting, can have but little significance since most of the mortality in trees left after cutting occurs during the first 5 or 10 years.

The growth of seed trees left after cutting was obtained by increment borings from 400 trees and was found to average 8.7 per cent per year by simple interest or a little over five per cent compound increase in volume based on the entire period since date of cutting. The seed tree loss described above is considered negligible in comparison with the growth per cent. Had figures for loss of seed trees during the first 13 years after cutting been available and combined with those for the period since that date, the average annual growth per cent would undoubtedly be greatly reduced, and the loss of seed trees would conceivably be far from "negligible." On the area studied, a net return of three per cent on the investment for seed trees alone is computed, giving no consideration to loss of seed trees occurring during the first 13 years after cutting.

Chapman's statement that the seed trees on the area studied near Urania, Louisiana, are almost completely fire resistant certainly does not hold for most of the longleaf pine region where recurring annual fires have been the rule. Evidences of damage from fires such as fire scars, trees blown down or burned down incident to fire damage, and

remnants of trees destroyed by fire, have been found in practically every cut-over area of longleaf pine studied by the Southern Forest Experiment Station.

The seed-bearing capacity of trees of various diameters and crown characteristics, growing at various densities and on various soils was arrived at by cone and fertile scale counts on selected trees. Assuming that 7,500 seeds equal one pound, the amount of seed per acre was computed to be 15.8 pounds, and per tree 1.78 pounds, produced in one maximum seed crop. Seed production per tree on dry sites was found to be more than twice as great as on wetter sites, generally preempted by hardwoods and loblolly pine. This means that it will require less than half as many seed trees to produce the required amount of seed for restocking dry sites.

Open grown trees produced twice as much seed as trees of the same size growing in groups. On the basis of crown volume, maximum production was reached at 3,000 cubic feet, the number of seeds decreasing on both sides on this point with effect of spacing remaining practically constant. When averaged on diameter and height the peak of production was reached by trees 15 inches d. b. h. and 50 feet in height. Decrease of seed production with increase in diameter above 15 inches and crown volume above 3,000 cubic feet seems very extraordinary. The shortest trees within the diameter class were the largest yielders. The ideal seed tree is described as follows: diameter 14.75 inches, height 65 feet, width of crown 10.3 feet, length of crown 28.7 feet, volume 213 board feet, seed production 46,632 seeds or 4.85 pounds of seed. Two and six hundredths such trees will produce 12.8 pounds of seed per acre, figured by Chapman as necessary for full re-stocking. The height of the ideal tree given here is 15 feet above that given in the table showing maximum yield as related to height.

The fact that the trees studied were not originally selected for seed tree purposes but were merely too poor or too small for logging in 1904, should be taken into consideration when drawing conclusions as to the number of seed trees necessary for restocking cut-over areas. Trees 10 and 11 inches in diameter proved to be very poor seed producers but the reason for this is the condition of these trees at the time of logging, when they were the poorest, suppressed trees in the stand.

Recommendations are given for number and character of trees to leave for seed and growth, but no mention is made of the importance of protection from fire and logging damage, without which protection minimum seed tree requirements seem futile. Leaving trees for a second

cut is of course dependent on economic conditions in any particular region.

The percentage of seed established as seedlings was obtained by comparing the seed fall per unit area as computed above with the seedling counts made the spring following fall germination. Counts were made on fifty 1/100-acre quadrats scattered mechanically over 91.8 acres. This establishment per cent was found to be highest on well drained upland soils free from hardwoods, and lowest on poorly drained lowland soils supporting hardwoods and loblolly pine. Removal of litter and competition by burning before seed fall raised the establishment on upland soils 300 per cent. Assuming that 1,000 established seedlings per acre at 10 years of age constitutes adequate stocking, 12.8 pounds of seed per acre were concluded to be sufficient for this purpose.

Factors influencing survival of seedlings are listed as fire, grazing, competing vegetation (annuals, grasses, brush, and seed trees), and disease.

The effects of two fires are described; the one occurring in September, apparently before growth had stopped, burning over a seven-year accumulation of litter and resulting in 85.4 per cent loss of seedlings under 8 to 10 feet in height; the survivors were three to five-year-old seedlings which had not begun to make growth and were typically resistant at that stage. Ten-year-old saplings from 8 to 10 feet high survived with trivial loss. A February fire burning through a six-year-old stand of one to three-foot seedlings resulted in a very small loss. Comparing the results of these two fires Chapman concludes that "such spring fires do not have the fatal effects of fall fires." In the case of the February fire no indication is given as to accumulation of litter and growing condition of seedlings, both essential points in making comparisons.

Many will not agree with Chapman's idea that no pine other than longleaf should be grown on typical longleaf sites for the reason that "these lands can never be rendered absolutely safe from fire." The feasibility of securing successful fire protection has already been demonstrated. In particular, one large lumber company in this region has been successful in keeping fire out of its holdings at a reasonable cost, with less than one per cent of the protected area burned over since the protection policy was adopted five years ago. Naturally, the question of the advisability of large scale planting of any species of pine other than longleaf on its typical site can not be answered until experimental plantings have been actually carried through at least one rotation.

On areas closely grazed by cattle during the summer of 1923 the loss of seedlings germinating the previous fall was 66.1 per cent at the end of the first season. On ungrazed areas the loss during the summer of 1922, of seedlings germinated the preceding fall, was 12.9 per cent. The difference between these figures is taken as the loss due to cattle grazing and could be accepted, provided the two areas and weather conditions during 1922 and 1923 were comparable. In 1925 at McNeill, Miss., the loss from all causes among 10,142 longleaf seedlings per acre on areas closely grazed by cattle was 17.5 per cent during the season following germination. In this case although the actual mortality was small practically all seedlings were very badly stunted and will probably fall out during the next season.

Competition by "grass sod" is given great importance as a factor working slowly toward the elimination of large numbers of seedlings. Tables presented in support of this contention show losses of 1922 seed crop seedlings due to all classes of vegetative competition during 1924, to be 16.77 per cent. Since this table does not isolate the effect of the factor under discussion its presentation here seems futile. Weather records for northern Louisiana for the year 1924 show precipitation to be 40 per cent below normal. This may well explain the losses mentioned.

Without protection from fire longleaf was found to have little chance of successfully competing with loblolly pine and hardwoods on sites favorable to these species.

Root competition from seed trees was found to result in complete blanks within a 10 to 15 feet radius from the trees.

The leaf spot disease, *Septoria pini,* which attacks longleaf pine seedlings up to three to five feet in height, is given credit for a loss of 34.3 per cent of all seedlings between one-half and two feet in height. It is said to cause greater losses than spring fires. This seems doubtful even on the area studied, since it is between heights of one to two feet that longleaf seedlings are most susceptible to fire. Furthermore it is believed that the infection on the area studied is much more severe than on areas more typical of the pure longleaf pine type.

Chapman recommends burning in the spring of the year in which seed matures and again four years later. The purpose of the first burn is to improve seed bed conditions and eliminate vegetative competition. The fact that burning at this time also removes valuable mulching material the absence of which may result in excessive losses of soil moisture during the first few months of the seedling's life, the most critical period,

is not mentioned. The second burn four years later is said to be necessary for control of leaf spot disease and reduction of competition before height growth of seedlings begins. Fire raging through four years' accumulation of litter certainly seems a risky proposition. Disease and some competition may be eliminated, but valuable accumulations of humus and mulch that seem more important than any vegetative competition that might exist on a typical longleaf site will also be consumed. The inference that annual fires are more destructive than periodic fires is very difficult to subscribe to.

To sum up: Chapman's data showing effect of fire on both seed trees and reproduction seem inconclusive, particularly as they are not substantiated by work along similar lines elsewhere in the longleaf pine region. The presentation of figures relating to seed production, however, represents a noteworthy advance on this phase of the problem and will have real value in the working out of management plans with longleaf pine.

E. L. Demmon and E. W. Hadley

Profit in Cutting Timber for a Permanent Yield. Presented before the Washington Section of the Society by W. W. Ashe, April 15th, and published in the Lumber World Review May 10, 1926.

Getting at forestry practice through the back door may become so common that the name plate and door bell will have to be moved. We do not hear so much now about Working Plans, not even "Working Plans that Work." Instead we have men like Ashe who are scaring the lumbermen into the practice of forestry by telling them how much it costs to lumber small trees and operate with small logs. In this article we are told that it requires more than twice as long to fell and cut up 1,000 feet mill measure in eight-inch trees as in 25-inch trees. When it comes to skidding the advantage with the large logs is even greater, for it takes three times as long to skid the same amount of lumber from eight-inch logs. Then there is the matter of grades. The difference in grades is obvious. Why cut expensive small trees yielding inferior grades when one can just as well cut high-grade lumber at slight expense by waiting a few years? Profit from forestry is what the lumbermen are looking for. Information of this kind should be very helpful.

A. F. H.

Mixed White Pine and Hardwood. By A. C. Cline and C. R. Lockard, with an introduction by R. T. Fisher. Harvard Forest Bulletin No. 8, Harvard Forest, Petersham, Massachusetts, 1925.

In this bulletin of 67 pages the very practical experimental work directed by Prof. Fisher in the Harvard Forest bears precious fruit, as

is only possible after years of such effort. Enlivened by an intensely interesting historical chapter by Prof. Fisher himself, there has been presented by the younger authors a very potent argument in favor of the mixed forest of pine and hardwoods for central New England, as against pure stands of white pine, which have been so much in vogue, but are now, as is well known, proving disappointing to many of their owners.

Prof. Fisher's introduction is directed mainly at the point that the pure white pine forest is not natural to New England but is, in a sense, a temporary type resulting principally from the wholesale abandonment of fields and pastures from about 1850 to 1880. The original forests, cut from the better lands to make farming possible, were mixed forests, according to all accounts, and there is now noted a very strong tendency for such forests to return, although the disturbance of natural conditions has introduced a horde of the less valuable hardwoods which are in some cases, particularly on the lighter soils, the keenest competitors of the pine.

At a time when the common conceptions of American silviculture are influenced all too largely by the literature referring to the remaining coniferous forests of the South and West, and when it is even argued by economists that only the softwoods will ever become scarce, it is indeed fortunate to have a voice of authority depicting the true conditions which do and must influence the policy of a special region, such as central New England, which, despite the abandonment of agriculture, isn't yet "poor" enough to be given over entirely to pines. In fact, we doubt not that much which is said of this region might be directly applied in portions of the Lake States, and that the silvicultural principles will bear consideration as to their applicability to the mixed coniferous forests of the West, such as the pine-larch-hemlock type. Who can say, for example, that the best western white pine will ever be produced in pure stands, without the help of the much-maligned "inferior" species?

It would seem that merely the historical fact that Nature, through the ages, had developed in New England a climax forest in which white pine was only one of the important elements, would be sufficient evidence that the culture of pure pine stands must sooner or later "run itself into the ground." For, if the attainment of the climax of a succession means anything, it means that the soil has reached its greatest degree of perfection and is therefore in suitable condition for the more exacting, usually the more permanent and profitable species, and certainly for the densest and most rapid-growing stands in the aggregate.

But this is somewhat abstract. The authors have scored a number of points which thoroughly clinch the argument. To our notion the most poignant and incontrovertible are these:

1. The finest "cork" white pine is produced in the long, slow struggle by which white pine attains (height) dominance in mixed stands. The product of short rotations in pure stands is a very inferior article. In no small degree the difference may be due to the pruning of pine by the branches of the hardwoods.

2. Pine in pure stands not only does not build up the soil by humus additions, owing to the height of the canopy and its low density, which permit free aeration and insolation, but, like any other single crop, it impoverishes it with respect to the elements most needed by the one species. A mixed forest "gets more out of the soil" in the same sense as a rotation of crops maintains a balance while increasing total production.

3. Unmixed forests are much more susceptible to disease and insect injury than mixed stands. Serious insect pests have already caused a good deal of alarm and actual damage to New England pine.

4. The mixed forest can be established more cheaply than pure pine. Especially on the better soils, as Prof. Fisher puts it "the maintenance of the (pure pine) type involves a costly and sometimes fruitless fight with hardwoods." It goes without saying that insofar as planting may be necessary to establish pine, and this is the most certain method,—though either clear-cutting in a seed year, or shelterwood, sometimes give excellent results,—a terrific waste is represented if the advance growth of hardwoods, or the sprout growth following slashing is not utilized. This lower installation cost seems to be, so far as present figures are able to show, the principal financial advantage of mixed pine and hardwood. Hardwoods admittedly yield less volume than pine, but may generally be expected to bring higher stumpage.

It is well to point out that the "mixture" of pine and hardwoods recommended, where the composition can be fully controlled, is one of small groups. In nature, it appears, pine usually reproduces only in the larger openings of the stands, and single pine trees, unless released by cleanings, are rarely able to rear their heads above the hardwoods, owing to the aggressive branching of the latter. Of a considerable group of pine seedlings, only one may survive to over-top the hardwoods and become the veteran which has inspired the admiration of all who know it.

This bulletin is recommended to the reader, whether or not he has a first-hand interest in New England timber, for the practical lessons of general applicability which it conveys; to one interested in the refinements of silviculture it reads like a romance.

C. G. B.

Preventing Damage by Termites or White Ants. By T. E. Snyder. U. S. Department of Agriculture, Farmer's Bulletin No. 1472. Government Printing Office, Washington, D. C., 1926, pp. 22, fig. 19, 6x9.

This bulletin is a popular description of the habits of termites and of methods of controlling them. Both the subterranean and nonsubterranean termites are considered. Termites have assumed great importance in certain regions and have done so much damage to wooden structures as to cause anxiety on the part of owners and builders of homes and business buildings. The bulletin is of great value to those who have termite infestations to control and to those who wish to prevent such infestations.

Sept. 11, 1926. E. F.

Anatomical Characters and Identification of the Important Woods of the Japanese Empire. By Ryozo Kanehira. Report No. 4, Department of Forestry, Government Research Institute, Taihokn, Formosa, 1926. 297 pp., 31 plates.

This book is in Japanese and therefore its use is limited. It is a large work and if it is as thoroughly done as the author's books in English it will be a classic in wood technology for the Japanese readers. The book is obviously a description of the woods of the Japanese Empire, one part containing a key and another a more extended description of individual species. English common names and botanical names appear throughout in English type. While the text is not available to but few outside the Japanese Empire, the 31 plates are of great interest and usefulness to any wood technologist. These present about 140 photomicrographs of woods and 48 drawings of radial sections giving ray characteristics. The photomicrographs and line drawings are excellent, and the legend of each bears the botanical name in English characters.

September, 1926. E. F.

Industrial Outlets for Short-Length Softwood Yard Lumber. By Edward M. Davis, Forest Products Laboratory. U. S. Department of Agriculture, Departmental Circular 393. Washington, D. C., July, 1926.

This bulletin presents information and suggestions for the lumberman who wishes to solve his "short-length" problem. By short lengths or "shorts" are meant boards under eight feet in length, of which a

large amount develops in the conversion of tapered logs into lumber or in the cutting out of defects from boards at the trimmer or in the planing mill. Of the several important branches of trade where there might be found outlets or uses for shorts only the "factory" trade was studied and only softwood needs were considered. Eighteen wood-fabricating industries were covered in this survey, and these use annually 858,000,000 board feet of softwood yard lumber, which is 56 per cent of all softwood lumber used for wooden factory products exclusive of boxes and crates, millwork and railway cars. These 18 industries already purchase 118,000,000 feet of their lumber as shorts, or 13.8 per cent of their total requirements. Of the 858,000,000 board feet used, 69 per cent or 595,000,000 board feet must be reduced to lengths under eight feet to meet the needs of their final products. There is thus an apparent outlet for an additional 477,000,000 board feet, but the author estimates "that these industries collectively might reasonably be expected to increase the percentage of short lengths in their total purchases of yard lumber from 13.8 per cent to 45 per cent."

The form of the shorts used by these industries was also studied, and the author concludes that "the potential absorption of shorts of square-edged softwood yard lumber is much greater than that of lumber worked to pattern." Another large potential outlet for shorts is for crating, machinery skids, blocking, etc., used by industries which use wood only incidentally. The industries studied include those making refrigerators, auto export boxes, ready-cut buildings, caskets and coffins, tanks and vats, stepladders, sign boards, agricultural implements, and others. A table is presented which shows the annual requirements of each industry in total and by type whether rough or dressed, or dimension, ceiling, flooring or siding, etc.; the amount cut to lengths under eight feet and the amount already being purchased as shorts. Less intensive data is presented for the industries making boxes and crates, railway cars, mill work, etc.

For each industry that was studied intensively the author gives the general scheme of construction of the product; the lumber consumption; properties required of the lumber; consumption of softwoods by species and items in per cent, and in some cases dimensions and grades required; the lengths purchased; items bought in short lengths; the cutting lengths; possible extension of use of short lengths; and sources of lumber. In these paragraphs it is to be noted that there is a considerable discrepancy between the amount of short-length material in

the completed product and the amount already purchased as shorts—a clear enough "lead" to the lumberman seeking a market for his shorts.

Lumbermen have in recent years come to admit that researches of this kind are helpful to the industry but only too few avail themselves of the data once it is published. Much of the solution of the short-length problem is up to the lumbermen themselves through their sales and trade extension agents. It can not be solved at once, but a careful study of this circular should suggest centers of attack on the parts of those having shorts to sell. With a careful study of the needs of the wood fabricating industries as presented in this circular, an appreciation of the difficulties involved in the purchase of shorts, and a faithful delivery to a prospective customer of shorts of only such character that will really serve his needs, much headway might be expected. It is encouraging to read that "industrial consumers are now purchasing short lengths in considerable quantities and may be looked to as potential buyers of three times the present quantity." Thus a good start has already been made. It must be remembered, however, that there are many factors that limit the use of shorts and that their introduction should not be "forced" where they may be a burden rather than a help. The lumberman should not look upon any new outlets discovered as dumping grounds and on the other hand the consumer should not expect something for nothing in the purchase of shorts. Extension of the use of shorts is endangered unless there is fair dealing on both sides.

Mr. Davis' study was apparently a very thorough one and the information he gives is something lumbermen have long wanted. The best the reviewer can wish is that lumbermen will study the circular carefully and take the initiative in an endeavor to reduce the discrepancy between the amount of short lengths actually used and the amount already purchased in that form.

September 6, 1926. E. F.

Relation of the Manner of Failure to the Structure of Wood Under Compression Parallel to the Grain. By Jacques L. Bienfait. Journal of Agricultural Research, Vol. 33, No. 2, pp. 183 to 194. Fig. 6. July 15, 1926.

This very interesting and instructive paper presents the results of an inquiry into the difference in the line of failure on the tangential face as compared to that on the radial face of a block of wood under an endwise compression strain. The inquiry was directed at the structure of the individual cells to determine why the plane of failure is almost constantly inclined in a tangential direction. Both hardwoods

and softwoods were studied including Southern yellow pine, Douglas fir, Sitka spruce, oak, ash, red gum, mahogany, sugar maple, birch and balsam, and over 500 specimens in all were tested. Slides were made of longitudinal sections including failure in various stages of development and examined by polarized light for any changes in the cell walls. Polarized light was found better than stains for bringing into relief minute changes in cell walls. To arrive at the genesis of failure by a study of its early stages "one's attention is drawn to the fact that the cell walls show changes attributable to stress even before a real failure can be considered to be present; and from that observation the necessity of studying the initial changes is obvious." An excellent photomicrograph is used to picture "slip planes" which are considered "the first indication that the wood has been subjected to severe longitudinal compression . . ." The development of slip planes is followed by the "formation of a localized injury, extending in a more or less definite line or zone across a number of adjacent cells. It can readily be recognized as the first definite indication of failure and for that reason it is termed the initial failure." An initial failure in Sitka spruce is pictured in a photomicrograph of Sitka spruce. The linking-up of numerous slip planes is clearly discernible, but this stage is not visible to the naked eye. The multiplication of these initial failures brings about a weakening "and thus forms an appropriate place for a gross failure to begin. The gross failure seems to start along, and to include, some of the initial failures, but its development is not always guided by the initial failures, for these are not continuous as a rule, whereas the gross failure is more or less so." "The grosser failures which are distinct to the naked eye can be seen under the microscope to be due to buckling of the cell walls." A distinction is made between buckling and crinkling. In the case of woods like Southern yellow pine having marked differences between early and late wood, the author found that the cells of the early wood are more likely to crinkle before they follow the general trend to buckle. The buckling produces an offset whose direction "predetermines the direction in which the region of failure is inclined." After disposing of several probable causes for the line of failure being inclined when viewed on the tangential face the author concludes that "in the stiffening effect of the medullary rays lies the probable cause. The medullary rays increase the resistance to buckling in a radial direction thus causing the line of failure to be inclined on the tangential face."

Sept. 9, 1926. E. F.

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Compiled by Helen E. Stockbridge, Librarian, U. S. Forest Service

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NOTES

Is Private Forestry Practicable in the United States?

Two Points of View

F. W. Reed:

The May number of the Journal of Forestry tells me that you are executive secretary of the Joint Committee on Recreation Survey, by *publishing your capital letter on propaganda.* In my mind there is no doubt but what there will be almost as little forestry in America when taxes are reduced and when fires are made rare as what we have today, unless there is as much money in forestry as there is in any other investment which I can make today, on any exchange, and which I can abandon or alter tomorrow.

I know this world of woods fairly well; and I have yet to see any private venture in forestry the risks of which I should care to share.

There is no private forestry in Central Europe (farm wood lots are never true forest tracts) unless you meet it on the entailed estates of the landed aristocracy and gentry where it finds a merely historical explanation for its existence; or in the tracts controlled by the Kymene, the Goodzeit, the Kopperbergs Stock companies in Finland and in Sweden where forestry is a means to an end, supplying some raw material for smelters and paper and sawmills, but never an investment *per se.* The forestry part of their investment does *not* pay their dividends of 6 or 10 per cent annually; manufacture does it, maintained largely on supplies of raw material secured *in the open market* at a price at which the company can *not* produce it. The case is clear: Dividends of 6 or 10 per cent from forestry can not be secured because trees, from a combined effect of volume increment, of price increment, and of value increment, can not produce a rate of money growth equalling 6 or 10 per cent. If the rate *were* obtainable, even without any expense whatsoever for taxes, etc., the damnable influence of compound interest exerted in 60 years or so would raise the value of stumpage (cost of production) beyond the possibility of competing with brick and concrete and steel, etc.

My feeling is that there is no sense in forestry producing stumpage worth $30 per 1,000 feet. Nobody will buy it. At 6 or 10 per cent interest, however, stumpage is sure to cost *that much or more,* to the producer.

What is the outcome?

The big lumber firms in the West have invested, per 1,000 feet board measure annually produced,

> $60 in timber
> $33 in mills and logging roads and equipment
> $ 8 in quick assets (bills receivable, etc.) or
> in all $101.

If they were to practice forestry, there would be in addition, some $50 worth of polewoods, of thickets, etc., forming an area some 10 to 15 times as large as that kept in old timber. These additional $50 would increase at once the cost of lumber production—at least—10 per cent on $50 or by $5 per 1,000 feet board measure, annually produced.

Polewood and thickets are "frozen assets,"—I would not have any if I could help it; they *decrease* the annual dividends and are hard to control. A lumber firm practicing conservative forestry can not compete because its cost of production is too high; indeed, in the example given, by $5 higher per 1,000 feet board measure, than are the production costs of destructive lumbering.

Is there no help or hope for real timber-forestry in the United States to be privately practiced?

No! It is impossible to favor those men who are willing to engage in it, with titles, hereditary seats in the Senate, and the prerogatives of a landed aristocracy. The case is hopeless. Forestry practiced on 300,000,000 acres of American private absolute forest land has no chance; the per-acre investment amounting to some $25 (as a guess) would involve a total fixed outlay of $7.5 billions yielding dividends of some 2 or 3 per cent or possibly 4 per cent.

Only the people, the states or the nation or the town being indirectly benefited by forestry, can afford to be satisfied with small and yet uncertain returns of forestry.

There will not be any private forestry in America because its dividends are unalluring, unattractive; and the privileges connected with it in Europe are absent in America, nay, are converted in America into burdens. I know what I am talking about; I have learned my lesson at Biltmore.

Thus there will be people's forestry only, or, which is the same, socialistic forestry. Maybe A. B. Cone's scheme of nation-wide forestry financed by national timber bonds is the needed arcanum.

Or—there is one more chance: private forestry made remunerative by national forestry bonds securing for the enterpriser of forestry

cheap money at 3 per cent or so, and thus preventing the damnable action of compounded business interest from taking its unalterable course.

We have national banking corporations secured by national bonds, at the people's expense, indeed. Why, we might as well have national forestry corporations, working and controlled under national charters, with stocks quoted on all exchanges and bought by everybody.

The unusual make-up of forestry as an investment makes unusual measures necessary to bring it about. Is it not true that all great industries were made possible in America by similar "unusual" measures, the steel industry, the transcontinental railroads, the chemical industry, the settlement of the prairies in 160-acre patrimonies, etc., etc. What we foresters need, is *less* scientific forestry and *more* knowledge of banking and economics and law-making; in a word, more common sense and a clear conception of the unusual, out of the ordinary, in forestry as an investment. There are no European precedents whatsoever; we must make our own way; and the best parallel to the national system of private forestry which I am advocating is the system of national banks, chartered and controlled and encouraged by the Nation.

Cheap taxes and safety from fires are some help; but in far-stretching investments, such as forestry, cheap money is the chief essential.

The balance sheet of a national forestry stock company would look somewhat as follows, per 1,000 feet board measure annually produced: (there might of course be companies with an abnormal arrangement of age classes, and why not?)

Debit		Credit	
Mature timber	$ 30	Common stock	$ 15
Polewoods	15	Preference stock	15
Thickets	10	Federal loans secured by cheap bonds	60
Cutover	5	Payrolls, bills due, interest and dividends	10
Saw and Papermills, etc., etc.	14		
Roads, logging equipment	18		
Quick assets	8		
	$100		$100

You see at a glance that under these conditions there is a good chance for private capital and energy and intelligence and venture to obtain commensurate reward.

In Europe, there are many similar enterprises though none in forestry; they call them "Gemischt-wirtschaftliche" or "state and private money mixed"; by these, the people retain some control, notably of monopolies such as coal syndicates, street car lines; and also, the people get what they need more cheaply than would be the case if either the people or else the individuals were acting alone.

Large companies alone are, today, justifiable; they are better steered—to a sawmill can be added a veneer plant and a furniture factory; vertical trusts (like the Steel Trust or International Harvester, controlling every raw material) are made possible; unlimited competition, the source of unlimited waste in all lines of primal production, is eliminated; and—the good public can share, by investments on exchange, in the prosperity of the large investment! We need large nationally chartered forestry stock companies.

C. A. Schenck.

Dr. C. A. Schenck:

I had been wondering what my purpose was in writing that letter to Zon, last May, about forestry and forestry propaganda; what personal profit would accrue from the mental effort expended. I have got my dividend on the investment in your letter of August 22 from Darmstadt.

Your prognostication of the future of private forestry in America, contains much that I hold with absolutely. It is indeed primarily a problem in finance; only secondarily one in technical silviculture. It is a race between the accumulation of annual rings in the woods, and the piling up of compound interest at the bank. If the former will win, and by a sufficiently wide margin, it will pay to grow timber, and capital will seek such investments. If the latter wins, or loses by only a narrow margin, there is nothing doing; capital will continue to seek other employment, automobile manufacture, rum running, or whatever activity gives better assurance of early and regular returns, and a margin of profit commensurate with the risk involved.

Amongst our leadership in forestry thought practical financial experience is limited pretty much to the simple process of receiving the periodic pay envelope, depositing its contents with the local bank, and next morning checking it all out again. Compound interest is largely an academic theory, and means little more than so many figures on a sheet of paper which can be altered at will with the aid of a good eraser. It is hardly surprising that some of us should fail to recognize interest as the all important carrying charge, far over-shadowing taxes and fire protection.

The timberland owner, and the lumber manufacturer, being good business men, and fairly well versed in finance, know perfectly well that capital must be fed, that it must have its periodically regular ration of interest, and that if it can not get it out of the woods it will go elsewhere for its nourishment. They accept the situation as an economic fact which can not be altered; therefore they say little about it. On the other hand they know that the tax rate is based on man-made rather than economic law, and that it is possible to get it changed; furthermore they must have some alibi when they are asked why they do not "practice forestry." Quite naturally they find it convenient to revive the old cry against the tax burden (the same old cry that has been ringing down the centuries ever since mankind first began to support a government), and to hope that by making it their excuse for not growing timber they may succeed in getting the rate lessened a little bit. If the academic atmosphere which permeates our forestry leadership could be leavened somewhat by the fresh air of financial wisdom and banking experience, perhaps, instead of spending thousands to investigate the forest tax problem (as is being done now) a lesser amount, productive of far greater results, might be devoted to the perfection of some financial scheme, such as you have outlined, by which the interest burden could be lightened.

Even our most technical investigations, our purely scientific research, should be tainted with finance. When we propose to leave seed trees to insure better reproduction; when we suggest raising the diameter limit in order that commercially mature, but silviculturally young trees may be left to grow larger, or when we recommend a thinning to accelerate the growth, we should learn to translate the results obtained into definite dollars and cents, and to balance them against the present profits that are being sacrificed—and should always remember the inescapable factor of interest. If we do not do this the results of our investigations will be of no practical value to the timber-growing investor. He is interested in such practices, not because they will produce better forests, but only if they will produce better dividends.

If I have interpreted your letter correctly, your conviction is that nowhere in the United States is the balance between rate of growth and interest in favor of the former, and that therefore private forestry, or timber-growing as a business venture, is nowhere possible unless it be government subsidized, or in some rare cases is undertaken as a means to an end, rather than an end in itself. Somewhere in your letter you have used the expression "absolute forest land." If you

confine your opinion to this class of land, and by it mean land whose natural productive capacity is so low that it never will be profitable to farm it under any conceivable economic conditions, I hold with you, body, boots, and soul—also my best golf pants. We need no further ring counts, or stump measurements, to convince us that the yellow pine of the Southwest increases in volume far too slowly to compete with the six per cent interest which is accumulating at the bank. The high dry ridges of the Southern Appalachians, we know, without additional scientific study, can not build up chestnut oak tissue fast enough to satisfy capital's demand for its regular ration of dividends. The same holds true for the lodgepole and fir forests of the Rocky Mountains, for the sandy soils of the lake states, and for portions of the longleaf pine belt.

Recently the U. S. Forest Service, under the Weeks Law, has purchased some fifty thousand acres of denuded pine land in Michigan at $1 per acre. It has hailed this deal as a stroke of business genius, and the cheapest buy in all the fifteen years that the Government has been engaged in such activities. It is the most expensive buy (from the financial standpoint), and the poorest investment that has yet been made for the Government. The original forest is gone; the new forest must be started by hand at a cost of $25 or more per acre; those who pretend to know, assert that it will take the new plantlings 150 years to become sawlogs. I leave it to you, with your mathematically facile pencil, to take this basic data and your old friend, Compound Interest, and figure out where the private investor would get off. I am satisfied, without dabbling in 1+ the Nth power, that even if one should give it to him "free, gratis and for nothing," if he should be relieved of all taxes, and if in addition the state should assume the full burden of fire prevention, he has no business with such land. On the $25 per acre cost of planting alone, six per cent interest, compounding annually, would swell the investment at the thirty-sixth year to $200, and at 60 years to $800. In the meantime where would capital get its periodic ration of cash revenue upon which to feed? Only Government is justified in owning such land, and it is so justified only because the general public good demand that it be restored to forest. Government is justified in paying $1 per acre for it, not because it is worth it, but merely because the vendor must be reimbursed for the cost and trouble of transferring titles.

The same principle applies to all of our "absolute forest land." Most of it, after the forest has been restored, will produce sufficiently

well to pay the annual protective and administrative costs, and the public, as owner, can take out its dividends in the form of watershed protection and recreational use (hunting, fishing, camping, mountain climbing, scenery, etc.). Possibly in time to come, on some of the better grades of "absolute forest land," there will be private timber growing, subsidized by Government, along the lines you indicate. It will be a case of Government contributing to the cost of the enterprise in proportion to the public benefits accruing, and leaving to its private partner those costs and cash profits directly benefiting him. My imagination pictures several obstacles and difficulties in the way of applying your scheme successfully, but your argument that it has already been done in other lines of activity should be convincing.

So far I have been agreeing with you. If, however, you intend to extend your remarks and your opinion to cover unqualifiedly every type, quality and grade of forest growing land throughout the whole country; if you intend to be understood that timber growing, as a private business enterprise, under any, every, and all conditions is nowhere possible, then I must begin to differ with you both as to opinion and as to fact. In addition to our "absolute forest land," we have a great deal of forest growing land of much greater productive capacity. A large portion of it is physically capable of producing farm crops, but is not now needed or being used for that purpose. At the same time the timber upon it will, and does grow faster than your compound interest accumulates.

Under the economic conditions that pertain in your country, where the population is dense, the demand for food crops, and for the land that will produce them, exceeds the supply, and where the wage scale is relatively low, it is inevitable that such land be all in agricultural use. It is equally inevitable, under the economic conditions prevailing in America, that farming should be profitable only on the richest and most productive soils, or on units large enough to permit of organized mass production, and the use of machinery reducing manual labor to a negligible item. There is now, and for many years there will continue to be, an overproduction of food crops, and a supply of physically agricultural land far exceeding the demand. The cost of manual labor, in relation to the sale value of the finished product, in every basic industry, is exceptionally high; more so in agriculture than any other line. The result is that between the "absolute agricultural lands" on the one extreme, which can be farmed profitably under the most adverse economic conditions, and the "absolute forest lands" on

the other, which it would not pay to cultivate for food crops under even the most favorable circumstances, we have a broad twilight zone, a vast acreage, of potentially agricultural, forest growing lands, which classify themselves, not by physical factors, but by the prevailing economic factors, as chiefly valuable for timber growing.

The comparatively low sale value of farm products, and the high cost of manual labor (an indispensable item of expense both in clearing and preparation, and also in cultivation itself) preclude their use for agriculture. The comparatively high sale value of stumpage, the fact that the trees are laying on annual rings fast enough to beat compound interest in the race, and the further fact that a minimum amount of manual labor is involved in the process, all point to worth-while profits from timber growing. For the undertaking to be successful, certain financial requirements must of course be complied with. The initial capital investment must be low enough to insure that the increased value through the growth of the timber, minus the annual carrying charges of interest, taxes, protection, etc., will pay a dividend. There must be sufficient young growth, or sufficient promise of getting it naturally, to obviate the need of artificial planting and the concomitant manual labor cost. The fire risk must be low enough to enable one to discount it in his calculations. For the land itself, separate from the growth upon it, one should ordinarily pay not more than $5, preferably less than $3 per acre. This can be done. I know of specific instances where one need pay no more than $1.50 for soil of the best productive capacity. To the bare soil value one can add in the purchase price an amount proportionate to the quantity, quality, and age of the young growth. In those cases which I have handled personally, it has never been necessary to pay for the young growth anything like its indicated investment value; simply a nominal sum to satisfy the vague idea that it must be worth something. On most tracts there is usually some commercially mature growth, that can be disposed of in a way materially to reduce the original investment cost.

In addition, since it is physically agricultural soil, there is the possibility that change in economic conditions may shift it over into the agricultural class, and give it a re-sale value much higher than its original purchase price. Moreover, the recreational resources, inherent in all forest property, viz., hunting, fishing, camping, etc., may often be commercialized in a way to increase the dividends on the investment.

You may argue that to buy land cheap, and then some years later to sell it dear for farming purposes, is not forestry but merely real

estate speculation. You may be right; but in the meantime the investment will have been carried through dividends derived from the growth of the timber. The expansion of a city out into the adjoining farm country not uncommonly makes it possible for the farmer to sell out at houselot prices. This does not alter the fact that in the meantime he has been raising cabbages, potatoes, or eggs, and has been making his living thereby.

In your calculations I note that you use the "1,000 feet board measure" as your unit. Presumably you are looking at the proposition through the eyes of the lumber manufacturer, the sawmill man, whose basic raw material is the sawlog, and who is used to having, and still wants, logs of a size and quality that it takes long years to grow, on even the best of lands. If he were our only customer, and if the sawlog of high grade were our only salable product, you might be right in your sweeping statement that timber growing will never pay anywhere. The lumber manufacturer, of course, has been in the past, and still is, by far the greatest consumer of stumpage, and it is more or less natural to base our timber growing calculations on the standards set by him. I doubt, however, if this is entirely logical, or necessary. Wood, particularly in those regions where conditions are the most favorable to the growing of it, is salable in other forms than sawlogs; for telephone poles, railroad ties, pulpwood, slack cooperage, turning wood, alcohol wood, naval stores, and a growing list of other things. For these purposes it is often worth just as much, per cubic unit, as the sawlog, and sometimes more. The trees do not have to be so large; they can be grown quicker, and therefore more profitably.

To my way of thinking, our unit of calculation should be, not the 1,000 feet board measure, nor the cord of pulpwood, nor the ton of bark, nor the railroad tie, nor the telephone pole, but the acre of forest growing land itself. We should consider *it,* what it will cost to buy it, and to protect and carry it, what it will grow, how much and how fast, and what price these products will bring. We should include in this list of products anything and everything that will have a commercial sale value, because being sound financiers we are interested first in the money which the acre will produce, and in its sawlogs only to the extent that they can be translated into money. If we take these basic factors of purchase price, carrying charges, rate of growth, and selling values, and mix them together in the proper way, with the proper modicum of compound interest we shall find that private forestry is not an entirely hopeless proposition, possible only under government

subsidy, or as an adjunct to a manufacturing industry. On the contrary there is more than one section of the country where favorable combinations of conditions render it feasible as a business venture *per se*.

As a matter of fact certain capitalists have already put money into it, and others are seriously considering the possibilities of following suit. I know of a bank itself which is holding a tract of growing timber, because by that process its money is accumulating faster than if it should loan it out on first mortgages.

It would make too long a story to attempt to describe any of these specific instances in detail. When next you come to this country, and I trust it will be soon, perhaps we can look at some of them together.

F. W. REED.

Wanted: Consulting Foresters

There will be little opposition to Mason's statement that the future timber supply of the United States must and will come from privately owned lands. Also there is little chance that forest practice on private land will be supervised by either state or federal governments. Therefore most of our future timber supply will be grown by private foresters, which means a very great many consulting foresters.

Already there is a large field for consulting foresters if it is properly developed. Two incidents may be given to show the demand: It was reported that in a southern state a well known cruising firm was employed to examine a cut-over tract. A non-technical man was running around with an increment borer and very little idea of what he was trying to do. In Kentucky a mining company decided to grow its own mine timbers. They were able and willing to employ a consulting forester but did not know of one. Through a county agent they got in touch with the extension forester of the state, who helped them get started.

A large proportion of our forest land is owned by estates, banks, corporations, and business and professional men of means. Many of them will be glad to practice forestry to some extent if they are shown that it will pay—and they can be shown.

Of course it is not an easy thing to build up a forestry practice, but neither is it easy for any other professional man starting in on his own. A man of proper training and good judgment who is willing to adapt technical methods to the financial situation of the owner should have little trouble in getting plenty of business in many sections of the country. If as much energy and advertising as has been used by so-

called tree surgeons is used by foresters there will soon be work for thousands of private foresters.

The papers and magazines are giving a great deal of space to forestry and consulting foresters should be able to cash in on this. Recently in a leading editorial the Lexington, Ky., *Leader* said, "Every landowner in the state should begin at once to reforest his estate." How much more effective that would be if there could be added "Lexington is fortunate in having an able consulting forester whose business it is to advise landowners on their forest problems."

The society can contribute a great deal towards the practice of private forestry by compiling a list of reputable consulting foresters. Regional lists should be sent to every member of the Forest Service and state forestry departments, agricultural extension heads in each state, chambers of commerce, etc. This should be one of the first jobs of the paid secretary!

CLARENCE HILL BURRAGE
Forester, University of Kentucky

Second Annual Conference of Forest Schools
August 30-September 2, 1926

The Second Annual Forest School Conference at the Madison Laboratory brought together representatives of the following forest schools: Robert Craig, Jr., University of Michigan; W. G. Edwards, Pennsylvania State College; George A. Garratt, Yale; C. H. Guise, Cornell; Ralph W. Hayes, Louisiana State University; J. V. Hofmann, Pennsylvania State Forest School; Raymond J. Hoyle, Syracuse; Barr N. Prentice, Purdue University; J. H. Ramskill, Montana; Henry Schmitz, Minnesota; Gilbert I. Stewart, University of Maine.

The representatives returned with the unanimous opinion that the profits and advantages of such a conference far exceed the effort. The benefits are many fold. It establishes a clearing house for research problems in forest products between the schools and the laboratory. Opportunities are also afforded for discussion of problems concerning the school. The broad scope and nature of the field covered by the conference are evidenced by the program.

Program

FOREST SCHOOL CONFERENCE
August 30-September 2, 1926, MADISON, WISCONSIN

MONDAY A. M.

8:30-9:00—Remarks ....C. P. Winslow
9:00-9:30—Conference Business.

9:30-11:00—II. Progress in Salvaging of "Short Lengths" of Softwoods as a Means of Increasing the Yield of Useful Material from Logs ....C. V. Sweet

I. Progress in the Manufacture and Use of Dimension Stock from Hardwoods.

11:00-12:00—(a) Typical Plants which are Increasing the Yield of High Grade Material from Their Logs by Manufacture of Dimension Stock ....A. O. Benson

MONDAY P. M.

1:15-2:30—(c) The Extent to which Dimension Stock Use has been Delayed by Lack of Adequate Methods of Seasoning. . R. Grabow

2:30-4:00—(b) The Extent to which the Consuming Industries have Aided in the Establishment of Dimension Stock Practices ....Raymond Hoyle

TUESDAY A. M.

IV. Developments Which are Aiding in the Utilization of Small and Isolated Holdings.

8:15-9:30—(a) Portable Sawmills...................Penn. State

9:30-11:00—(b) Cooperative Marketing R. D. Garver, Theodore Macklin

11:00-12:00—VII. Extent to Which Pulp and Paper Industries are Aiding in Extending the Use of Hardwoods and of Mill and Logging Waste ....J. D. Rue

TUESDAY P. M.

V. Progress in the Balanced Marketing of Timber from Mixed Stands.

(b) By Supplying the Raw Material to Existing Industries.

1:15-2:30—White fir and Western hemlock ....C. V. Sweet

2:30-4:00—(a) By Bringing Industry to the Raw Material—Co-ordination of Industry on the Cloquet Plan ....Howard Weiss

WEDNESDAY A. M.

VI. Progress in Marketing Timber That can be Salvaged only by Immediate Consumption.

8:15-9:00—(a) Fire Killed Timber ....R. D. Garver

9:00-10:00—(b) Chestnut ....J. V. Hofman

11:00-12:00—III. Some Successful Combinations of Secondary and By-Product Manufacture with Primary Plants Which Have Re-

sulted in the Use of Low Grade and Short Length Materials.................................George Morbeck

WEDNESDAY P. M.

1:15-2:30—XI. Developments in the Box Industry Affecting the Quality and Quantity of Raw Material Required and the Utilization of Low Grade Lumber......................C. A. Plaskett

2:30-4:00—VIII. What Can and Can Not be Expected of the Chemical Industries as Aids to Wood Utilization.........L. F. Hawley

THURSDAY A. M.

8:15-10:00—IX. Progress in Turpentining Practice as Bearing upon Management of Slash and Longleaf Pines. 1, 2, 3, 5..Eloise Gerry

10:00-12:00—IX. Progress in Turpentining Practice as Bearing Upon Management of Slash and Longleaf Pines...........Austin Cary

4. Methods of Forest Management for Dual Purpose Pines.

THURSDAY P. M.

1:15-3:00—Discussion of Future Plans for Forest School Conference ....Committee

3:00-4:00—Committee Reports and Unfinished Business.

FRIDAY P. M.

Forest School Business.

The papers and discussions brought out many practical and useful points in the correlation of utilization and management. Short lengths and dimension stock open up new markets for much material that is now difficult to handle. Salvaging material killed by fire, disease or insects hinges largely upon the possibility of immediate transportation. This question led to very profitable discussion of commodity rates and possible reductions in general freight rates. This has been accomplished in some localities and there is great need for further work.

The turpentining industry was very thoroughly discussed. The production of naval stores and timber were shown to be entirely practicable and desirable as a forestry policy.

REPORT OF THE JOINT COMMITTEE OF THE SECOND FOREST SCHOOL CONFERENCE

A. Function of Committee. The function of the undersigned committee, as we understand it, is to lay out plans for future conferences, and for other possible means of coordinating forest products research with the other fields of Forestry.

Before we can lay out plans, we must first lay out what this conference seeks to accomplish.

B. Objectives of Conference. The objectives of this conference are:

(1) To exchange information on the progress of utilization research.

(2) To coordinate utilization research programs.

(3) To discuss ways and means of adjusting utilization research and practice, and silvicultural research and practice to each other.

Objectives (1) and (2) require no comment. Objective (3) needs to be emphasized to all foresters.

Silviculture too often tends to assume that conditions affecting utilization are more or less stable, whereas the actual fact is that research is causing radical changes which call for vital changes in management plans.

Likewise utilization is probably not taking into account the changes which will flow from silvicultural research.

We are far from an intelligent adjustment between even our present conditions of using and growing forests, but still further from an intelligent forecast of probable future conditions.

C. Means of Coordination. In furtherance of the foregoing objectives, we recommend the following:

1. Continue the Annual Conference. We especially urge that more Forest Schools attend next year's conference.

We favor this year's plan of a joint informal discussion of a selected objective topic as better than last year's plan of formal instruction in a selected field of research.

Digests. Written texts of material are impracticable but we suggest that next year digests of all papers be furnished to all in attendance.

2. Continue Utilization Lectures at the Schools. Lectures by senior specialists when they happen to travel near a school are preferable to formal tours by less specialized individuals.

3. Cooperative Research Projects. Annual lists of research projects suitable for schools should continue to be issued, but they do not go far enough.

School men should discuss their research programs with the Laboratory Section Chiefs concerned *at the time of the conference* to see if more *joint projects* can not be found. Forest Schools are often the logical agency for working out the *local application* of the more gen-

eralized projects of the laboratory. Formal cooperation on such projects will help the schools to get funds and the laboratory to get its results applied. Formal cooperation with the school as an institution rather than with the individual school worker will help insure responsible execution. Obviously there should be discrimination by all concerned in choosing projects which have a distinctive local application and which fit the school's available personnel and equipment.

4. *Research Work at Allied Schools.* As pointed out last year, research is needed on many problems bearing upon forestry, which neither the Forest Service nor the Forest Schools are equipped to undertake. Forest Schools may often have an opportunity for placing such work in the universities of which they are a part. The conference should be a means for segregating such projects and laying plans to interest the proper institutions in them.

5. *Cooperative Extension Work.* Each school is obviously a proper agency for getting the results of research applied to its region.

There are untouched possibilities for such work. The results of products research, for instance, are published in technical notes and bulletins. Each school should get not only library copies of these publications, but a supply of the ones most applicable to its region for use in answering inquiries and doing educational work. The laboratory should facilitate such use of its publications in so far as possible.

6. *Regional Utilization Programs.* Research has now accumulated such a mass of results representing so many stages of local applicability that there is need for segregating for each region a brief list of the things which are especially important and which a majority of foresters agree are ready to be applied in that region.

The Forest Service is already proposing to compile such lists. The annual conference presents an admirable opportunity for getting the criticism and cooperation of the Forest Schools and consulting the state foresters.

We urge that any forest school contemplating the installation of a small sawmill unit give serious consideration to the practicability of the French portable band type of mill.

7. *Research Details.* Foresters from the schools should seek opportunity for details to the laboratory for actual research work in specialized subjects, and the laboratory should encourage such details.

IN CLOSING THE FOLLOWING RESOLUTION WAS PRESENTED

Whereas, the Forest Products Laboratory has been instrumental in bringing about the second annual meeting of the Forest Schools, and

whereas, the laboratory has arranged the program and given freely of the time of those specializing in utilization in presenting the new developments to the conference and taking part in the discussions, and whereas, all accommodations of the school representatives were arranged by the laboratory staff, and whereas, the laboratory secured for the conference such excellent contacts with the developments in the chemical field as presented by Mr. Howard Weiss, in co-operative marketing as presented by Professor Theodore Macklin, and the relation of the turpentine industry to forestry practice by Mr. Austin Cary. Therefore, be it resolved, that the deepest appreciation and gratitude of the Forest Schools be extended to the Director, C. P. Winslow, for his personal interest and conduction of the conference as chairman. Be it further resolved, to express our appreciation and indebtedness to all of the members of the laboratory staff who assisted in the program and discussions and maintained the interest by their attendance. Be it further resolved, that copies of these resolutions be placed in the hands of Col. W. B. Greeley and the Secretary of Agriculture.

J. V. Hoffman.

Danger of Frosts Studied at Wind River Nursery

A. G. Simson of the Pacific-Northwest Forest Experiment Station has made some interesting observations on the need for protecting seedlings (principally those of Douglas fir) during the early spring after growth starts, and again in the fall before the newer growth has hardened, and when the seedlings are quite sensitive to frost, a temperature of about 28 degrees Fahrenheit, being assumed to be damaging. These results are embodied in a file report (March, 1926), "Temperature Distribution and the Effect of Seed-bed Covering."

Simson's findings indicate that, using 10-ounce burlap as a seed-bed cover, a minimum temperature of 28 degrees under the cover may be expected only when 21 degrees is reached outside. At higher temperatures, the insulation has less effect, amounting to only two degrees Fahrenheit when the outside temperature is 42 degrees Fahrenheit.

Examination of the weather records for the nursery, covering 15 years, shows but one occasion when the temperature at the main weather station has dropped as low as 21 degrees in April, May, September or October. Considering only May and September, which are the most critical months from the standpoint of unhardened growth, the lowest record is 26 degrees, occurring twice in the spring month.

It is, therefore, obvious, that so heavy an insulation as that used is unnecessary for any normal risk, and Simson brings out the point that its continued use in spring or fall only tends to increase the sensitiveness of the plants.

However, by means of thermometers placed at various points in the nursery, which had a very gentle gradient to the East, it was established that the lowest point of the nursery is subjected to minimum temperatures 2.5 degrees lower than the main weather station. Therefore, this section needs the more ample protection. Fairly reliable frost forecasts would do away with the need for very frequent covering of the beds. This is a subject which Simson has developed in a companion paper, "Forecasting Minimum Temperatures at the Wind River Nursery." The system of forecasting followed is based on humidity conditions at 5 P. M.

Professor Tor Jonson Comments on His Trip to United States

"My trip has been productive from all points of view, and I feel very satisfied indeed to have been able to see your country. I also desire to thank all American foresters for the extraordinary courtesy and hospitality they have shown me and Mr. Johansson during our four months in America. We wish you all the very best success in the activities in which you are engaged now and in the future."

SOCIETY AFFAIRS

CALIFORNIA SECTION

Report of the Secretary for the Season 1925-1926

The officers for the season of 1925-1926 were: T. D. Woodbury, U. S. Forest Service, Chairman; Emanuel Fritz, University of California, Secretary. Eight meetings were held, as follows:

September 14, 1925—Hilgard Hall, Berkeley. Business meeting. Section and parent society matters received attention.

October 6, 1925—Ferry Bldg., San Francisco. Special Meeting. "State Forestry." Occasion of visit of Assoc. of State Foresters.

November 13, 1925—Hilgard Hall, Berkeley. "Problems of Forestry Education."

December 17, 1925—Ferry Bldg., San Francisco. "Fire Protection Devices and Methods."

January 15, 1926—Ferry Bldg., San Francisco. "Blister Rust Control."

February 11, 1926—Ferry Bldg., San Francisco. "The Relation Between Recreation and Forestry."

March 19, 1926—Hilgard Hall, Berkeley. "The White Fir Problem."

April 20, 1926—Hilgard Hall, Berkeley. Business Meeting and talk by Mr. G. M. Cornwall on his Southern trip.

The meetings in general were well attended and productive of progress in the understanding of Society matters and enlightenment on the subjects up for discussion. As was the custom in previous years, the time devoted to current "business" was held at a minimum thus giving the bulk of the evening to the programmed topic. Business was conducted principally at two meetings called solely for that purpose. Meetings held in San Francisco were preceded by an informal dinner at a local restaurant. Another custom that was continued was the appointment by the Section chairman of a special chairman to conduct the discussion of the topics on the program. Men outside the society who were known to be especially interested in the topics were invited, thus adding a great deal to the success of the discussions. Guests at program meetings included representatives from the lumber industry, the grazing industry, the recreational field, the forestry club of the University of California, and others. Following each meeting the proceedings were mimeographed and sent to each member.

These mimeographed "proceedings" entailed considerable time and expense but were considered very valuable especially to those members who reside too far from the San Francisco Bay region to attend meetings. Announcements of coming meetings were sent out in mimeographed form also, thus giving greater space for acquainting the members of the business and topics to be discussed.

The California Section now has:

45 Senior members
63 Members
9 Associate members
9 Section associates

Total 126

Of these 55 are residents of the San Francisco Bay region.

The table following indicates the varied pursuits or occupations of the membership:

59 U. S. Forest Service
5 Other Government Bureaus
3 State and County Forestry Departments
13 University of California-Faculty and graduate students
11 Foresters in private employ as foresters
19 Lumbering
2 Lumber Association Secretaries
14 Miscellaneous fields, including ranching, lumber-trade journalism, railroads, public office, retired men, etc.

Through its active membership committee the California field has been very thoroughly gone over for men eligible to membership. The chairman of this committee, Mr. C. E. Dunston, keeps a card index record of all eligibles from which can be learned whether an eligible has been proposed for or elected to membership, or whether the invitation to join has been declined.

Dues for the year were again set at $1.00 for members resident in the San Francisco Bay Region, and 50 cents for those living in other sections of the State and too far away to attend section meetings. The secretary takes pleasure in recording the interest of local and out-of-town members in the California Section nearly 90 per cent of the Section's members having paid dues the past year. The expenditures equalled the receipts and were almost solely for mimeographing and postage.

Officers for the season 1926-1927 are C. L. Hill, Forest Service, Chairman; Emanuel Fritz, University of California, Secretary.

Special projects of the Section included interesting associate members in subscribing to the Journal of Forestry and of endeavoring to obtain advertisements for the Journal. Six subscriptions were obtained but no advertisements. A start was also made in a study of the extent to which private owners of timberlands in California practice forestry. This study is a part of the national study conducted by the parent Society.

Berkeley, Calif., Sept. 15, 1926.

EMANUEL FRITZ, *Secretary*

Get Behind the Society

A check of the membership list of the Society on May 13, 1926, disclosed the following situation:

Fellows	6	Dues paid......	6	Delinquent	0
Senior Members.	512	Dues paid......	406	Delinquent	106
Members	547	Dues paid......	376	Delinquent	171
Total					277

On that date, four and one-half months after the due date, twenty-five per cent of the membership of the Society had failed to pay up. The financial status of the Society as presented in the March issue of the Journal should have convinced the members that we faced a precarious situation. With our limited funds, and the constant need for their *use,* it is imperative that dues be paid promptly, and I respectfully and urgently request those members who are behind in payment to send their checks in as soon as possible.

Since coming to Washington and assuming some responsibility for the affairs of the Society in President Dana's absence I have realized —as I never had before—the amount of work which has to be done in conducting the business of the parent organization. It takes money and time to handle those things which just have to be done if we are to keep a semblance of a well organized body. To handle expeditiously and well those many projects, which in their doing would bring credit to the Society and its members, I am convinced that increased financial support is a *sine qua non,* and I am confident that the members will rally to the support of their officers in the latter's desire to make the Society a strong and ably functioning body.

PAUL G. REDINGTON,
Acting President.

Program of the Annual Meeting of the Society of American Foresters Philadelphia, Pa.

DECEMBER 29-30, 1926

The meeting will be held in conjunction with the annual session of the American Association for the Advancement of Science.

WEDNESDAY, DECEMBER 29

9:00–10:30	Society Affairs. (Presentation of Reports of President, Secretary, Treasurer, Members of Council in charge of admissions, Executive Council, and various committees).
10:30–12:30	The practice of forestry on private lands. Papers and discussion.
2:00– 3:00	Continuance of discussion of morning topic.
3:00– 5:00	*Open forum for discussion of any technical or general forestry matters on which members have indicated their desire to present.

THURSDAY, DECEMBER 30

9:00–12:30	Weather and Fires. Papers and discussion. (It is hoped to make this a joint meeting with the Meteorological Section of the A. A. A. S.).
2:00– 5:00	Discussion of Society affairs such as the Program of Work; Refinancing; Sectional Co-operation; Survey of Forest Practice; Constitutional Revision; Membership Questions; Announcement of Election of New Officers, etc.

Charles Lathrop Pack Prize Contest for 1926

Twenty-five manuscripts were received by the committee in charge of the Pack Prize for 1926, by November 1, the last date for receiving papers to be entered in the competition. The decision as to the award will be announced at the Annual Meeting of the Society, December 29 and 30, in Philadelphia.

*Members desiring to present matters at this session should indicate the subject and the time needed for presentation to the Secretary, Atlantic Building, Washington, D. C., by December 15.

Sections of the Society of American Foresters for 1926

Allegheny

C. P. Wilber, Chairman, State Forester, State Office Building, Trenton, New Jersey.
G. H. Wirt, Vice-Chairman, Department of Forests and Waters, Harrisburg, Pa.
H. R. Condon, Secretary-Treasurer, Broad Street Station, Philadelphia, Pa.

California

C. L. Hill, Chairman, 1408 Grand Ave., Piedmont, California.
Emanuel Fritz, Secretary, 305 Hilgard Hall, Berkeley, Cal.

Central Rocky Mountain

E. W. Tinker, Chairman, Forest Service, Denver, Colorado.
J. W. Spencer, Vice-Chairman, Forest Service, Denver, Colo.
H. D. Cochran, Secretary, Forest Service, Denver, Colorado.

Intermountain

R. E. Gery, Secretary, Forest Service, Ogden, Utah.

Minnesota

Henry Schmitz, Chairman, University Farm, St. Paul, Minn.
S. A. Graham, Secretary, University Farm, St. Paul, Minn.

New England

Karl W. Woodward, Chairman, New Hampshire University, Durham, New Hampshire.
H. O. Cook, Secretary, State House, Boston, Massachusetts.

New York

O. M. Porter, Chairman, c/o American Paper & Pulp Association, 18 East 41st St., New York City, New York.
John Bentley, Jr., Secretary, Cornell University, Ithaca, New York.

Northern Rocky Mountain

R. H. Weidman, Chairman, Forest Service, Missoula, Montana.
W. M. Nagel, Secretary-Treasurer, Missoula, Montana.
T. C. Spaulding, 3rd member of the Executive Committee, Missoula, Montana.

North Pacific

A. W. Cooper, Chairman, c/o Western Pine Manufacturers Assn., Yeon Building, Portland, Oregon.
A. H. Hodgson, Secretary-Treasurer, U. S. Forest Service, Portland, Oregon.

Ohio Valley

Ovid A. Alderman, Chairman, Wooster, Ohio.
Bernard E. Leete, Secretary, 1313 Kinney's Lane, Portsmouth, Ohio.

Southern Appalachian

E. F. McCarthy, Chairman, Room 610, New Medical Bldg., Asheville, N. C.
R. S. Maddox, Vice-Chairman, State Forester, Nashville, Tenn.
F. W. Haasis, Secretary, Appalachian Forest Experiment Sta., Asheville, N. C.

Southwestern

Hugh G. Calkins, Vice Chairman, U. S. Forest Service, Albuquerque, New Mexico.
Quincy Randles, Secretary, Forest Service, Albuquerque, New Mexico.

Washington

G. H. Collingwood, Chairman, Forest Service, Washington, D. C.
Franklin W. Reed, Vice-Chairman, 3245 Cleveland Ave., N. W., Washington, D. C.
John B. Cuno, Secretary-Treasurer, Forest Service, Washington, D. C.

Wisconsin

B. H. Paul, Chairman, Forest Products Laboratory, Madison, Wisconsin.
E. M. Davis, Secretary-Treasurer, Forest Products Laboratory, Madison, Wisconsin.

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